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Project-based Learning in Industrial Environment from the Perspective of Students, Teachers and Company

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Abstract

Project-based learning is an effective learning methodology in which students are confronted with complex problems with multiple solutions in a real working environment and where they should acquire and implement new knowledge. This methodology allows students to have a closer contact with real problems and help them developing both technical and soft skills. This article is based on a project-based learning experience, developed by University of Minho students in partnership with a subsidiary of an international industrial company that produces automotive components. The work aims to analyze the impact of this type of project, which follows the PLE (Project Led Education) methodology, on all the involved stakeholders identifying the main advantages and disadvantages, the importance of these projects and the relevance of their replication and existence. With this purpose, a survey and interviews were carried out to company employees, production chiefs, students and teachers. Results showed that this project was considered very successful by all the stakeholders. Almost all participants of this experience demonstrated interest in taking part on it and evaluated this type of project as relevant for all. Unquestionably, these projects should keep on existing.

Keywords: Project based learning, project management methodology, stakeholders, survey, interviews

1 Introduction

Over the years, learning through projects has become increasingly important for the proper and sustainable development of University students. Several authors have published their experiences and points of view on such projects, where students were able to acquire various skills through close contact with professional reality. This type of learning can be implemented by performing internships during the first years of University education (Katajavuori et al, 2006) or during projects on the University course (Harrison et al, 2007; Okudan and Rzasa, 2006). Helle et al (2006) expressed that there are three models of project work in education. The first model refers to the project exercise, with a particular subject and with the purpose of enforcing knowledge and techniques obtained in a known context. The project-component is the second model that works in conjunction with various subjects and is more interdisciplinary. This kind of project is more related to real world concerns. Finally, the third model refers to an approach to the course as a whole, instead of considering the traditional subjects.

The University of Minho has been playing a key role in developing projects that integrate contents from various curricular units over one semester, according to the methodology PLE (Project Led Education) as described in Powell and Weenk (2003). The first experience at the University of Minho with this kind of projects dates back to 2002 and, since then, the teaching methodology associated with it has been continuously developing and evolving (Lima et al, 2007). These team works, which follow the principles of an education based on projects – Project Led Education – give a new meaning to the learning process, as this is done trough the resolution of complex problems by teams of students in a real industrial environment (Lima et al, 2005). According to Lima et al (2005), this type of project "is focused on the students and on their performance in order to achieve the competencies defined", fostering the development of several types of skills. Drummond et al (1998) claims that students are able to develop skills more efficiently if they are in contact with the work reality, than if they are subjected to the traditional way of learning. Students have the opportunity of acquiring the skills required for each one of the curricular units involved in this project and at the same time developing soft skills such as communication skills, time management or projects management (Helle et al, 2006; Powell and Weenk, 2003). Gibb (2002) refers that students should also acquire entrepreneurship skills, such as creativity, leadership and capacity for initiative. Martinez et al (2007) also emphasize these entrepreneurship skills, paying particular attention to autonomy, decision-making ability and ability to solve problems. As proposed by Johnson and Johnson (1991), another important part of this type of projects is also the development of one particular skill, the conflict management. Students can assimilate all the contents and issues related to the various curricular units associated with the project and

apply the acquired skills on the resolution of real problems. Students have an integrated vision of problems as they appear in real life situations in an industrial context anticipating their experience in the labor market.

This article is based on a project that took place at the University of Minho, in the framework of the Integrated Master in Industrial Engineering and Management, 4th year. That project was developed, for four month – from October 2010 to January 2011 – together with a Portuguese company, located in the northern city of Trofa (in Douro region, Oporto district), which manufactures components for automobiles. In this company, especially due to its large dimension, it was only studied the functioning of one productive section, where are produced radio and air conditioning modules for cars. Thus, this project was based on the educational methodology PLE (Project Led Education) and consisted of applying the knowledge, lectured during classes, from the five Curricular Units that students have during a semester. There were thirty seven students, divided in five groups of six students and one group of seven. The students had to analyze the productive system and then suggest some improvement proposals using the contents of the Curricular Units involved in the project.

In order to assess the impact of the implementation of the developed project and of the methodology followed in the process, they were described and analysed the opinions and the perceptions of the various stakeholders involved in this project (from the University: students, professors involved and professors not involved in the project; from the Company: production chiefs and employees), trying to identify problems and potential areas for improvement. It is also intended to assess the perception of the company, finding out their degree of acceptance of the ideas suggested by students and if they plan to implement their proposals, understanding the usefulness and the efficiency of this kind of projects. The study of this University-Industry partnership was developed using survey and interviews that were conducted by the authors of this article. In this context, the survey was made to the company employees and to the company members. Professors and students were interviewed, as well.

2 Methodology

In order to analyse and understand the opinion of the various stakeholders involved in this project, an experimental research work was carried out based on the information collected through survey and interviews. The survey and the interviews were conducted three months after the end of the project and were made in Portuguese and then translated to English.

The questionnaire survey was delivered to the company employees and later collected. The questionnaire survey was composed of twenty two questions formulated with five-point Likert scaling (1 is “never” and 5 “always”). Four different issues/aspects that are important to analyse were considered in the design of the questionnaire survey: i) the project ii) the employees’ expectations iii) the company acceptance and iv) the students’ role. This anonymous survey was distributed to the employees during the working hours and answered during their lunchtime break. It is important to refer that the population considered for this study is consisted only by women with an average age of 37 (from 21 to 57), who are machine operators and have, in average, 16 years of work in the company. To analyse more efficiently the information collected from the survey, the data was treated using the statistic software SPSS – Statistical Package for the Social Sciences (IMB).

Regarding the interviews it was important to distinguish four different groups of persons because of their different involvement and role in the project: i) the company members ii) the professors involved in the project iii) the professors not involved in the project and iv) the students. Relatively to the company members, they were interviewed two chiefs of production and the head of the Logistics Department. The interview was conducted simultaneously to all three and was recorded so as not to lose any information. The interview consisted of twenty three questions, some directly related to the project, others related to the students’ behaviour and others concerning the University-Company relationship. In what concerns the group of professors involved in the project, five professors were selected for the interviews. The selection criterion was the professors’ awareness and knowledge about the work carried out by the students. The selected professors are also the ones with whom the students had a more close contact and easy access. These interviews were also recorded and consisted of seventeen questions that can also be dived into three aspects: i) the project itself ii) the students’ learning process and iii) the Curricular Unit lectured by the respective professor. In relation to the group of professors non-participating in the project, the selection criterion was their expertise in relation to the project topics. In such way, it was decided that one professor of each area would be interviewed, namely: Industrial Management, Numerical Methods and Statistic, Optimization and Operational Research, Human Engineering and Economic Engineering. These interviews were also recorded and consisted of eleven questions about the project, the students and the Curricular Units. Finally, concerning the students, two students were randomly selected from each project group. These recorded interviews were conducted simultaneously to the two members of each group and had twenty six questions regarding i) the project, ii) the

students behaviour, iii) the Curricular Units involved and iv) the company. The students' opinion is one of the most relevant to take into consideration in this study since the project was carried out by them being extremely important to their learning and education process.

3 Survey and Interviews Analysis

In order to analyse the survey and the interviews more efficiently, the population was divided in two groups – the University group and the Company group. In the University group it was scrutinized the students and professors' perceptions (those directly involved and those not involved in the project) and in the Company group it was explored the company members' perception, both the employees and the production chiefs.

3.1 University

The students and professors' opinions show that this type of project has a lot of advantages for both the University and the Company. It is important to refer that the professors' perception is based on their professional experience along several years, while the students' perception is only based on this project in particular (due to the fact that this was their first contact with this kind of projects).

The students have the opportunity of establishing their first contact with a real company, dealing with real problems of day to day business. It is no longer an academic exercise and the students are able to apply the knowledge acquired at the University to solve real problems and they can suggest various improvements that can be implemented in the company where the study was carried out. Another benefit brought by this project is that students learn to solve real problems working in teams and may achieve good communication skills.

> "The students begin to see the practice, the reality, how companies work (...)"
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

> "I think the greatest advantage is for us. (...) It was our chance of seeing how things work out there. (...) what is taught here at the University is not always as linear out there and things do not always work so well."
>
> Student (Group 3)

This project brings advantages for the University itself too, since the University and Course's name and reputation are spread and divulged. If the students manage to do a good job and if there are no problems attached, the University can maintain a good relationship with the Company in order to establish future new projects.

> "This interaction is most beneficial to students and to the University than to the company (...). The projects that exist in the course are very tight on time, a semester is too short. Yet, in my opinion the company has, in the end, a perfect notion of what a group of students is capable of, what the course is capable of, what the University itself is capable of."
>
> Professor involved in the project (Activity Area: Optimization and Operation Research)

According to several stakeholders' opinion a project of this kind can be very interesting, for the Company, as students bring new ideas, different approaches and updated information on technologies and methodologies. The University is always updated and can freely give the knowledge the Company needs to succeed. Students can have a fresh new look over the problems and propose different ways of solving them.

> "I think that it brings tremendous advantages to the company for one simple reason: the company is concerned about the operational management (satisfy orders, customers and deadlines) and forget that sometimes it's necessary to take someone who thinks about the way they operate and how they can improve their business. And I think that students, some students, are even a stone in a pond to these companies because they benefit enormously from the work they have there."
>
> Professor not involved in the project (Activity Area: Industrial and Systems Management)

Concerning problems that may arise from this kind of project, professors and students showed different opinions. In the professors' opinion, the problem that can induce more the good project development is the coordination of the professor's team (the ones involved in the project). Another problem is that some students give more importance to the project than to the information transmitted in the Curricular Units (CU), not acquiring the entire knowledge taught throughout each one of the CU's along the semester. Finally, the professors involved in the project also told that some of the students didn't do their "homework", i.e., they do not prepare the questions for the visits to the Company so they cannot get all the information needed.

> "When students go to the company trying to understand the productive system, they can't get there and just ask how to make the Production Planning and Control. It is a question so difficult to answer that no one responds to. So they have to do a previous homework in order they will be able to ask more direct and precise questions."

Professor involved in the project (Activity Area: Industrial and Systems Management)

> "A potential disadvantage of this project, (...) may be the fact that this project is something different from other Curricular Units, where basically you come to classes (...) have to study (...). And this project does not usually have these things you dislike. You basically have to work, have a space to work (...) And then the tendency that is sometimes observed is that this project is almost everything for you, in a semester you dedicate 90% of the work to this project but it's only worth 30% of the grade (...) there is something that is unbalanced."
>
> Professor not involved in the project (Activity Area: Human Engineering)

On the other hand, students point out the conflicts among the group as the worst problem. To this project it is needed a strong team work that sometimes lacks in the groups. To the students, the coordination of the work schedules and the maturity of some members of the groups were mentioned as problems as well. At last, they considered that the role of the tutor is very important too and sometimes he/she did not correspond to the students' expectations and needs.

> "The main problems are the lack of team work (...) sometimes one of the group members do not work and some other times, there are conflicts within the group (...). The relationship with the company may also be a problem because sometimes there is not enough openness to consider the students recommendations. Then there's the side of students. Sometimes they are not enough responsible, they are not mature enough to have this relationship with the company (...). Another problem that may occur is the role of the tutor, who may not always be present."
>
> Student (Group 2)

In spite of these different opinions, there are a few problems in which both of them agreed on. The difficulty to access to the information and the lack of availability by the company members were the most commonly pointed out problems. Other problems are the short time to do the project, the long time needed for the visits to the Company and the travelling costs to the company, due to its distance (approximately 30Km). Another problem very mentioned, mainly by the students, was the lack of communication between the University and the Company.

In what concerns the students learning process, with this kind of projects, students are able to acquire two types of skills – the technical skills and the soft skills. Concerning the technical skills, they can comprehend the Curricular Units' concepts better by applying them in the project context. Relatively to the soft skills, there are many important ones to consider, such as team spirit, time management, communication skills, critical power, projects management, organization, discipline, conflicts management and resolution in the work team.

> "I think it's the team work, to have the power of initiative, critical thinking (...) a good relationship with people, to have a position of humility, being an entrepreneur but also know how to listen to what people have to say (...), be diplomatic."
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

Comparing the students' learning process when they do this kind of project with the traditional learning process (classes, tests and academic works), it is possible to understand that the majority of the interviewed considered that this project is a capital gain, especially for students. Even though most of the people agreed, there were some professors who said that students cannot neglect the learning basis and the scientific knowledge.

> "The students are more motivated. And then we have the fact that they see how companies apply the knowledge we teach here (that students sometimes think it is very vague and not applicable). (...) This motivates students to be more attentive in class, trying to figure things out, so of course they learn more."
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

> "I think that in some issues the students can keep a registration, can remember more. But they learn a practical case and they may not learn a general theoretical situation which could then be applied to different variations in many scenarios. They are there just to study a scenario, which is reductive (...). We should learn the gravity law and not only observe how the rock falls."
>
> Professor not involved in the project (Activity Area: Optimization and Operation Research)

When confronted with the question about the existence of more of such projects throughout the course, the interviewed showed different opinions. The professors involved in the project demonstrated interest in having a similar project also in other previous course years and even one in every course year, but with a smaller dimension. The professors not involved in the project said that this project should be kept in the 4th year or, possibly, there could be one project of this kind in the 3rd year. In the remaining previous years there could be visits to companies for students to have more close contact with business reality. The majority of these non participating professors would like to see their Curricular Units involved in this type of projects too. The

students all agreed that there should be at least another project of this kind in the previous year but not one in every year because the Curricular Units of the first years are not the most adequate to this kind of projects.

3.2 Company

The company involved in this project had never participated in a project of this kind. However, the company believe that students could bring new ideas, new technology, more updated tools and, at the same time, it could bring a capital gain. They also assumed that they would have time to receive students and to support them in their activities, being available to answer to all students' questions.

> "Typically, the visits were scheduled, the students settled a time to be here and I knew that in that time I had to be available (...). I never lacked the will to receive students."
>
> Company's Production Chief

Once the company had access to the students' improvement proposition/suggestion, they could understand the potential of their application. Some suggestions were already implemented (the lighting improvement in the workplace), others seemed to be more difficult to implement (the layout adjustment) and others are into consideration (the improvement of the replenishment of materials to production lines).

> "There are proposals that could be implemented but not easily. There are solutions that involve drastic changes in the layout (...) changing the layout is not an easy thing to do."
>
> Company's Production Chief

Nevertheless the good reception from the company to students' ideas it was not always possible to answer to students' doubts and questions. It was the case when students asked for some information that was considered confidential and the production chiefs could not give them a direct answer. Another situation was when the required data was not confidential however the company members to make public that kind of information need their superiors' permission.

The analysis of the obtained results was made taking into account three different categories answers: i) positive answer, the higher the score the more positive is the answer ii) negative answer, the lower the score the more positive is the answer and iii) informative answer. In this way, for each the 22 questions of the questionnaire survey, the average of the scores for the individual questions were computed, see Figure 4, where the green colour represents the type i) questions, the orange colour represents the type ii) questions and the grey colour represents the type iii) questions. For the positive answers (type i) questions) an average evaluation higher than 3 (solid horizontal line) has a positive meaning and corresponds to the expected score value for these questions. An opposite behaviour is expected for the questions type ii), where an average score value less than 3 represents a positive perspective (orange bars).

Analyzing Figure 4 it is possible to recognize that the answers given to the questions corresponding to the orange bars (type ii) questions) are considered positive. For example, in questions 19 (P19: "Have you felt any discomfort due to the presence of students in your workspace?") and in 21 (P21: "Have you ever had to interrupt your work to answer questions raised by students?"), the average score values are lower than 2 (or "not much") meaning that the employees support that the presence of students on their workplaces was not incommodious.

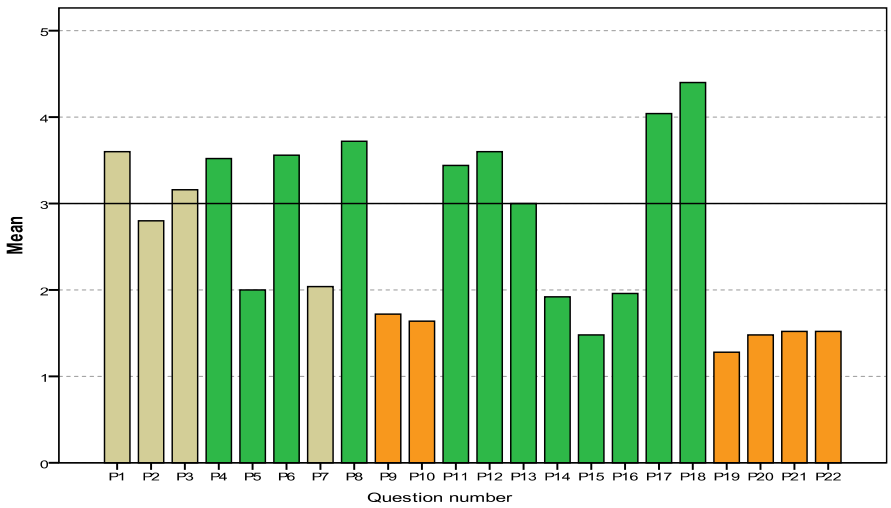

Figure 4: Mean values for each question of the survey

Regarding the green bars, questions with a positive answer, it is possible to observe that 8 on 12 answers given by the employees are positive (average score value higher than 3). The question with the highest positive average score corresponds to question 18 (P18: "Did you felt well treated by the students?") this might mean that students had a correct attitude and posture when approached the employees. Nevertheless, for four questions, the average score obtained is below 3. After analysing the possible causes of these low values, it was possible to conclude that they were normal, since the questions were related to the improvement and changes of the employees' workplace. As this study was conducted three months after the end of the project, it is possibly that this time was not enough so that the changes proposed by the students have been implemented and their results properly analyzed. Regarding the grey bars, informative answers, the average scores obtained were as expected, except for the question 7 (P7: "Your superiors always notify you in advance when students visited the company's facilities?"). In average, the employees demonstrated that they were "not always" informed regarding to the students' visits.

Comparing the production chiefs' and the employees' perception, both agreed that their relationship with students during the project was extremely good. The questions 18 (P18: "Did you felt well treated by the students?") and 20 (P20: "Would you like to have had less contact with the students?") could demonstrate that the employees felt comfortable with the presence of the students, and confirmed by the production chiefs answer in the interviews:

> "I think that our relationship with the students was great, it couldn't have been better!"
>
> Company's Production Chief

Concerning the employees' attitude while the students were in the shop floor, again both the employees and the production chiefs agreed. In general, the employees considered that, even though there were outsiders analyzing their performance, they did not feel pressured and had the same behaviour while doing their job (P10: "Do you think you worked/behaved differently when students were in your workspace?"), with an average lower than 2 ("not always"). The production chiefs believe that employees' attitude has not changed, however they felt more useful by answering the students' questions and motivated by the students' interests regarding their work.

In general, it is possible to conclude that there weren't negative aspects that affected the correct running of the project. It is also important to refer that the majority of the company members showed some interest in having this type of project in their company again and shortly. However, with some exceptions, since not all the employees looked very enthusiastic with this project. The average score value obtained for the question 4 (P4: "Do you think that it would be interesting to repeat this type of project in this company?"), despite of being positive, was only of 3.5 (Figure 4) meaning an answer between the "may be" and "without an opinion". This opinion is not influenced by the employees' working years at the company, meaning that, regardless the years of service at the company, the opinion concerning the interested in repeating this project is similar ($p > 0.05$).

3.3 Comparison between University's perception and Company's perception

After analyzing the two separate perceptions, both of the University's and the Company's, it is important to relate them to understand completely this duality. The students' posture and attitude during the project was considered, by the involved professors, as good. In spite of their big motivation, some students had a punctuality problem, arriving late to meetings and to the company visits. The professors also said that a few students showed assiduity problems and even a little lack of responsibility, but, the majority of the students were very interested, enthusiastic and motivated to do a good job.

> "In general, students were punctual within tolerance (10min) (...). Most groups were committed, although there were some students or groups who didn't showed much responsibility.
>
> Professor involved in the project (Activity Area: Human Engineering)

> "What I felt over the years can be resumed in two distinct phases: an initial phase of concern by the students, they do not quite know what will happen to them; the information is often slow to arrive because they don't control it (...). In the second phase, I notice a great willingness of students to work and the company's visits become very motivating."
>
> Professor involved in the project (Activity Area: Optimization and Operation Research)

The production chiefs also referred the punctuality as a small problem. However, they said that students were very interested in analyzing the productive section and considered it as a very stimulating experience.

> "The punctuality was very bad, even though, by the end of the project it started to be better. I think that they were very interested, that sometimes it became a little annoying (...). Questions repeated twenty times it´s a little exhausting but, in general, I think it was a great experience (...). Some students faced the project in a very positive way, transforming it in a good challenge."
>
> Company's Production Chief

The students themselves considered they were interested and committed, but sometimes some conflicts arose among the group. They also mentioned the punctuality as a problem of some group members. Overall, they stated they had the right posture and attitude to accomplish this project.

Regarding the communication between students and company members (production chiefs and employees), it is relevant to indicate that everybody have the perception that there might be a little problem. This communication problem occurs due to a language/ vocabulary barrier which affects the good understanding between both parts. This language barrier takes place because of the use of different terminologies, used to describe some activities in the production system, that are different at University and Company.

Students consider that the relationship between them and the company members was very good. They believe they were well received and that the company members were very collaborative and helpful all the time, so they felt comfortable in the company.

> "In terms of personal relationship it was good, the production chief was an impeccable person and the employees were very nice (…). The relationship was very informal."
>
> Student (Group 3)

> "We were received very well and they were very helpful, we had no reasons to complain."
>
> Student (Group 4)

> "I think it was good. In the beginning, it caused an impact to the company employees because they didn´t know the students, but after some contact with them we had always a good relationship and we could even exchange a lot of information."
>
> Student (Group 6)

4 Conclusion

As part of the PLE method proposed by Powell (2003), the project that was the basis of this article was intended to allow students to examine a section of a production system in a real industrial unit and propose suggestions for improvement. This article aimed at analyzing the perceptions of various stakeholders involved in this process, which could be grasped through survey and interviews conducted three months after completion of the project. In order to more carefully and deeply analyze the results, the two main entities involved in this project - University and Company - were considered separately. With regard to University, they were interviewed students, teachers involved in the project and teachers not involved in the project. In the company they were interviewed two production chiefs and the head of the logistics department and was performed a survey to the employees of the section under study.

After analyzing the survey and the interviews it was possible to conclude that, in general, this project was beneficial for all parts involved. Students had, in an early phase, their first contact with professional reality and had the opportunity of developing their creativity and applying their ideas and knowledge acquired in class. This project was also important for students to achieve certain soft skills important for their future careers, such as project management, time management, teamwork, leadership and communication skills. The companies had the opportunity of receiving some interesting and feasible suggestions, based on a different view on the problems and using updated techniques and knowledge.

These projects can also serve as a marketing strategy, as the University can promote itself as well as its courses and projects. A great added value pointed out by all stakeholders was the good relationship between students and teachers and all the company members. However, although this project has brought undoubtedly many benefits, there were also some problems, such as the communication between students and the company members, since the terminology used is different, the restricted access to information because of the confidentiality of some of it, the conflicts within the group members and also the distance that the students had to travel to reach the company. Another problem often mentioned in interviews, both by teachers and heads of production, was the lack of punctuality of some students.

In conclusion, this project was very fruitful and beneficial for all parts involved. The vast majority of participants expressed its interest in participating and in repeating this experience and considered that these projects are crucial for a good students' learning process and should undoubtedly continue to exist.

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