Project Development in an Entrepreneurship Setting

Pedro Fonseca
Universidade de Aveiro, Instituto de Telecomunicações
Aveiro, Portugal
ORCID: 0000-0002-7313-6959

***Abstract*—Project based learning contributes to instil a wider view of the professional activities in the students, in contrast to classroom lecturing. For a practicing Engineer in the workplace today, expected skills go beyond the technical skills and working in a team. A mandatory requirement is the ability to interface with a customer: how to understand the client needs and how to deliver a suitable result. This paper describes the results of an experiment on Project based activities in a course unit of an Engineering degree, that aims at creating an environment that promotes the acquisition of entrepreneurial skills. In this course unit, groups of 4 to 6 students develop a project to solve a problem proposed by a company. Each team acts as an engineering company, providing a service to their customer. During project development, a member of the University staff and a representative of the company, which acts as a customer, supervise each team. To create an environment similar to a business environment, student teams participate in a bid for the projects they want to develop, competing with other groups. All groups start by preparing project proposals that the companies assess, similarly to what they would do with proposals from subcontracted companies. At the end of this process, the proposing companies rank the proposals received and a match is made between companies and students' preferences. The choice for this approach results from the perception that it fosters students' autonomy and responsibility and, thus, better prepares students for the transition into professional life. The success of the project will depend on the level of commitment in preparing their proposal, which requires, among other things, clearly understanding the client needs, developing an adequate solution and being able to communicate their ideas in the proposal. A survey, conducted at the end of the academic year, assessed the results obtained with this process. The responses show generalized approval of this model by both parties involved (students and supervisors) showing that, at least from their perspective, the proposed assignment process attended the expected results.**

Keywords—Capstone projects, Project based learning, Industry involvement, Team work

I. Introduction

Project based learning is considered an excellent approach to promote acquisition of social skills, as well as providing an opportunity for students to apply knowledge in a practical context. As such, it provides a significant ground for understanding the relevancy of non-technical skills in the profession and the social relevance of Engineering. Project based learning contributes, in this way, to instil a wider view of the professional activities in the students, in contrast to classroom lecturing. For a practicing Engineer in the workplace today, expected skills go beyond the technical skills and working in a team. A mandatory requirement is the ability to interface with a customer: how to understand the client needs and how to deliver a suitable result.

This paper describes the results of an experiment on Project based activities in a course unit of an Engineering degree. In this course unit, groups of 4 to 6 students develop a project to solve a problem proposed by a company. Each team acts as an engineering company, providing a service to their customer. During project development, a member of the University staff and a representative of the company, which acts as a customer, supervise all teams. A few months before the start of classes, companies submit their proposals in an online platform. A group of lecturers screens these proposals to ensure that they are aligned with the course unit objectives, that the level of difficulty is adequate and that the project does not involve any kind of time-to-market pressure. This step of the process follows a procedure close to a peer-review in a conference or journal paper, where several reviewers assess the proposal in several items. When necessary, these lecturers propose adjustments to the proposals, in a negotiation process with the company. Students receive the approved list at the start of classes.

In order to create an environment similar to a business environment, student teams participate in a bid for the projects they want to develop, competing with other groups. All groups start by writing project proposals that the companies assess, similarly to what they would do with proposals from subcontracted companies. The choice for this approach results from the perception that it fosters students' autonomy and responsibility.

The remainder of this paper is organized as follows. Section II presents the background on the paper subject. Section III describes the organization of the project-based course unit that used the proposed project assignment process. Section V presents the survey results and, finally, Section VI draws some conclusions.

II. Background

Project based learning, or PBL, is recognized as an effective strategy to involve students in their learning process, contributing to a student centred approach of the teaching-learning process (e.g., [1], [2]). Blumenfeld et al [3] define PBL as a "comprehensive approach to learning" to "engage students in the investigation of authentic problems". PBL requires a question or problem that organizes the students' activities, which result in artifacts or products. Still according to these authors, PBL offers students a realistic and contextualized problem-solving environment.

In the European Higher Education Area, the Bologna Process has reinforced the focus on strategies and methodologies that place students in the centre of the learning process [4], even in areas that do not relate to the technical field [5]. Motivation and purpose influence strongly the students' learnings. Baillie and Fitzgerald [6] studied the situation of students at risk of demotivation and drop-out. Amongst the intervention proposed to address the problem, they mention providing creative problem-settings, including problems proposed by the industry. Belagra et al. [7] report how PBL can contribute to students' motivation and learning gains, showing a positive result for PBL, when compared to traditional settings.

The characteristic of PBL make it particularly suited to promote the development of non-technical skills, also referred to as transversal skills, transferable skills or soft-skills (e.g. [8]). Both academia and accreditation boards have worked in order to integrate activities to promote these skills in the students curricula, an issue that has been studied for some time (e.g., [9], [10]), as these are considered essential by the recruiters. Recruiters often mention that graduates they integrate in the work market do not possess the required skills [11]–[13], which makes this a relevant issue to address. van Hattum-Janssen and Vasconcelos [14] describe the issue of integrating soft skills in an engineering curriculum by means of a case study with an approach relying on project-based learning. Musa et al. [15] report on a survey conducted with engineering students to conclude that PBL contributes to the development of soft skills that are relevant to the workplace. The positive effects of PBL are also reported by Vogler et al [16] when analysing the development of interdisciplinary projects. In their work, they study students' learnings while developing a project in the context of a client-contractor relationship and how instructors should organize their intervention. They stress that students will not automatically develop hard or soft skills without some support by the instructor, who should therefore provide the necessary instruction.

In many Engineering degrees, capstone course units are seen as a fundamental component of students' preparation. Holdsworth et. al [17] define capstone as a course unit providing "opportunities for a student to apply the knowledge gained […], integrating [different] capabilities and employability skills" that occurs usually in the final year of a degree. In a similar trend, Ward [18] defines capstone projects as a course unit "designed to bring all aspects of an undergraduate student's experience together by allowing students to apply the breadth of knowledge and skills they have learned." The learning approaches for capstone course units are multiple. Besides project based activities, other possible approaches include problem based learning, case study analysis, work placements and internships, immersion experiences, service learning and volunteering [17].

Ward [18] identifies a set of elements contributing to effective project based capstone experiences: organizational structure, duration, faculty involvement, project sourcing and industry sponsorship. In his study, he analyses the structure of several capstone course units of top ranked universities in Quacquarelli Symonds and Times Higher Education rankings, identifying five common elements in all of them: prior problem-based courses, an emphasis in group projects, a model following a design-build-test model, active industry involvement, and sequential assignments.

III. Course Unit Organization

The course unit, entitled Industrial Project, aims at making students acquainted with the process of developing engineering projects. The Learning Outcomes state that:

- Students will be able to apply project management methodologies to solve a problem in Engineering, namely in terms of their planning and execution control.
- Students will be able to develop a specification document from the presentation by the customer of a need or problem to be solved and, from there, develop or realize the product or service.
- Students will be better able to work as a team.

For that purpose, during one academic year, students, organized in groups with 4 to 6 members, develop a project to solve a problem proposed by a company. Reference [19] presents the course unit in more detail.

A few months before the start of classes, companies submit their proposals in an online platform. A group of lecturers screens these proposals to ensure that they meet the course objectives, that the level of difficulty is adequate and that the project does not involve any kind of time-to-market pressure. This check is essential to guarantee that students' learning gains drive all the project development process, not companies' interests. When necessary, these lecturers propose adjustments to the proposals, in a negotiation process with the company. Students receive the approved list at the start of classes.

To promote an entrepreneurial setting, student teams develop their project in a role-playing context. The teams perform as an engineering company, providing a service to the customer, the company that proposed the problem. This role-play is onset from the beginning of the course, as the first task of student teams is to participate in a bid for the projects they want to develop, competing with other groups. All groups start by writing candidate project proposals that the companies assess, similarly to what they would do with proposals from subcontracted companies. This is a task that many students feel uncomfortable with, as it is a new situation for them. Conversations with the students indicate that the process of creating a proposal to develop future work, which must evolve from an idea or concept that is not of their own, is their major source of concern. To help students in this task, a lecturer accompanies the team's work and students have sessions with company representatives, explaining how to prepare a proposal. These representatives are company members, usually with an engineering background, that are professionally involved with the preparation of engineering services proposals, similar to what students need do prepare. This kind of support to students is aligned with the recommendations on [16] about the need of some support for the students to acquire the desired soft skills. To limit the dispersion of students' efforts, each team is allowed to prepare up to three proposals. Student teams may choose to prepare fewer proposals, and they rank their proposals by order of preference. At the end of this process, the proposing companies rank the proposals. Any company may reject some or all proposals, if it finds them to be inadequate. Based on the preference indications from both student teams and companies, course unit supervisors match companies' proposals with students' proposals. The matching tries to guarantee, as much as possible, that student teams and companies get their first choice. After this process is concluded, student teams start working in the project they have been assigned, under the supervision of one lecturer and one representative of the company. The supervision by a company representative is important, to guarantee the active involvement of industry in the project development, as pointed out in [18].

IV. Problem Statement

The course unit studied in this paper recurs to a process of assigning projects to student teams where student teams compete with their peers for the project they would like to develop, and the company that proposed the project chooses

what they consider to be the best proposal. To the authors knowledge, the only reference in the literature to a similar process occurs in [18], concerning the National University of Singapore, where students also follow a competitive bid for the project title they wish to develop. But, in this case, there is no reference to the selection process, and it is unknown if this approach is still used, as the consultation to the NUS web pages did not provide any insight into this topic.

This setting was proposed for several reasons. One, was to promote the commitment of both the companies that proposed the challenges and the student teams developing the project, as both would have a saying in the final decision: students would apply to their preferred projects, and companies would select a team only if they found the proposed solution adequate. No student team would get a project they had not applied to; and no company was assigned a team they had not approved (companies may reject all proposals, if none seems to be adequate). Any choice involving only one party, such as having the students select their project, with possible ties being solved by some deciding criteria, such as GPA (Grade Point Average), could possibly result in the other party not being committed to that choice. At another level, promoting Entrepreneurship is one of the course unit objectives. As such, having students preparing their proposal for the project development that will be subject to a competitive selection places them in a context similar to companies bidding for a contract and improves accountability on the students' side: a well written proposal will increase the chances of getting the favourite project. The success of the project will depend on the students' level of commitment in preparing their proposal, which requires, among other things, clearly understanding the client needs, developing an adequate solution and being able to communicate their ideas in the proposal, promoting training in communication skills.

This paper addresses the question of whether the proposed selection process effectively contributes to the commitment of students and companies and to a better fit between them, and if, as a consequence, it leads to better final results. Being an instructional approach that has just started, the participants survey seemed to be the best approach to collect data on this issue.

V. RESULTS

Most of the 14 projects developed during the year were completed, with varying degrees of success; in only two situations, the student teams were unable to produce a working deliverable responding to a minimum set of requirements. The environment in this course unit contributed to a better performance of students, taking assessment marks as an indicator. Fig. 1 presents frequency distribution of students' pass marks, in a scale of 0 to 20, 10 being the minimum pass mark. The performance profile of students enrolled in this edition of "Industrial Project" (grey bars) follows the overall behaviour of all students in the degree (black bars), showing that the performance of students in this cohort is aligned with the rest of the degree programme students. The results obtained by the students in "Industrial Project" course unit are clearly superior to their overall results. The average mark increases, resulting from the shift to the right of the marks frequency distribution; the mode moved from 12 in the GPA of enrolled students to 15 in the pass marks distribution in "Industrial Project".

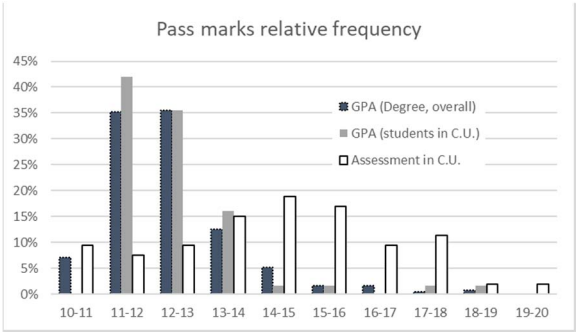

Fig. 1. Frequency distribution of students' marks.

At the end of the academic year, a survey was conducted to collect the opinions of students and companies regarding the organization and implementation of the course unit. This is a general survey, covering a wide range of aspects concerning the course unit. This edition of the course unit had the participation of 68 students and 27 supervisors. Approximately half of the students and half of the supervisors responded to the survey (Table I).

Table I - Respondents to the survey.

	Students	**Supervisors**
Entire population	68	27
Number of respondents	34	13
Response rate	50%	48%

To assess the effectiveness of the proposed selection process in attaining the desired goals, which were to promote the commitment of students and proposing companies, creating a better fit between them, and contributing a better final result, the following group of questions was included in the questionnaire:

- In assigning projects to groups, a model was adopted in which groups of students applied through a proposal bid, which were subsequently selected by companies. Give your opinion on the following statements regarding this process of assigning projects to groups:
  - P1: The process of project assignment to groups is adequate to Industrial Design course unit
  - P2: The process of project assignment contributed to a higher level of commitment between companies and students.
  - P3: The process of project assignment contributed to a better fit between companies and students.
  - P4: The process of project assignment contributed to a better final result in the implementation of the projects.

The participants expressed their opinion by responding in a 4-level scale, from "Totally disagree" to "Totally agree".

The responses of students and supervisors are presented in Table II to Table V and Fig. 2 to Fig. 5.

Table II. Responses to the question P1

	Totally disagree	**Disagree**	**Agree**	**Totally agree**
Students	3%	6%	55%	36%
Supervisors	8%	8%	54%	31%

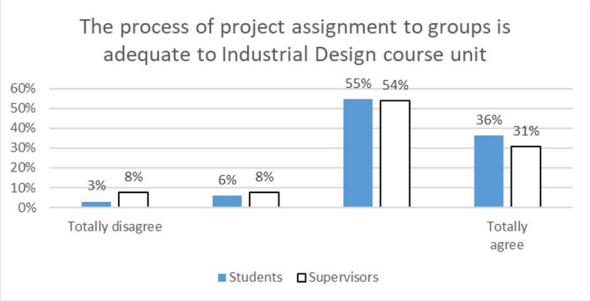

Fig. 2. Responses to question P1

Table III . Responses to the question P2

	Totally disagree	Disagree	Agree	Totally agree
Students	9%	9%	52%	30%
Supervisors	0%	23%	62%	15%

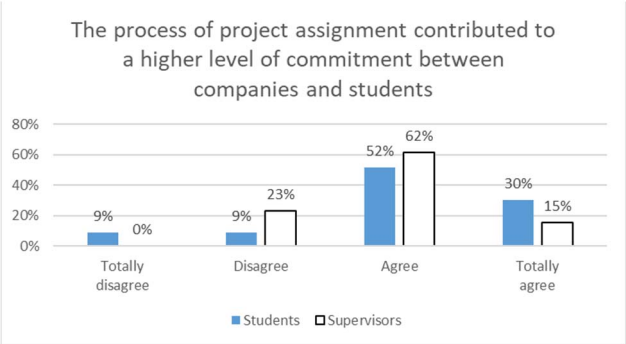

Fig. 3. Responses to question P2

Table IV. Responses to the question P3

	Totally disagree	Disagree	Agree	Totally agree
Students	3%	12%	48%	36%
Supervisors	0%	31%	46%	23%

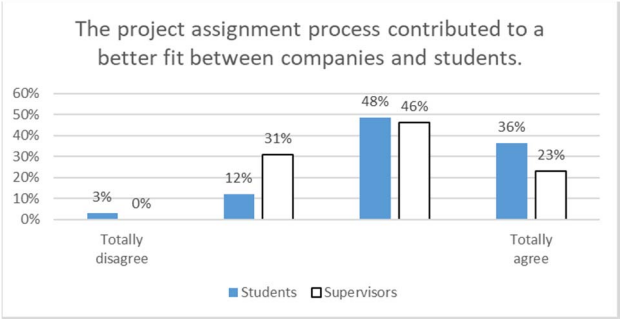

Fig. 4. Responses to question P3

Table V. Responses to the question P4

	Totally disagree			Totally agree
Students	3%	24%	58%	15%
Supervisors	0%	23%	62%	15%

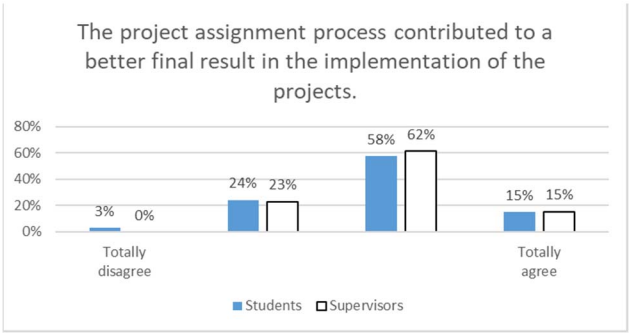

Fig. 5. Responses to question P4

The overall analysis of the responses to the questions concerning the project assignment process reveals a generalized positive appreciation of the project assignment process. It is also patent that students and supervisors' opinions are aligned, as their responses present a similar pattern in the relative frequency of response choices. The most positive assessment comes from the statement "The process of project assignment to groups is adequate to Industrial Design course unit": 91% of students and 85% of supervisors answer "Agree" or "Totally agree".

One of the purposes for proposing the bid-based project assignment process was to increase the level of commitment between student teams and supervisors. The responses are clearly positive. On the students' side, 82% of respondents declare, "Agree" or "Totally agree"; as for the supervisors, that impression is shared by 77% of the respondents. When comparing the responses to the commitment level (question P2) with the responses concerning the fit between students and companies (question P3), the positive impression increases slightly on the side of the students (84% declare "Agree" or "Totally agree") and decreases on the side of the supervisors (69% declare "Agree" or "Totally agree").

Finally, question P4 addressed the issue of whether this choice process had any impact on the final result. The vast majority of students (73%) and supervisors (77%) agree, totally or not, that the project assignment process contributed to a better result in the implementation of the projects.

VI. Conclusions

This paper presented an experiment on dealing with assigning projects proposed by companies to student teams that will develop them. After companies presented their challenges, students are called to prepare and submit, in a competitive bid, proposals to develop the challenges they found to be the most interesting or challenging. The companies take their part in the decision by analysing and ranking the received proposals. The final match is done by the

University staff, aiming at providing a balanced distribution of projects by the teams and taking care that, as much as possible, all teams get a project they have chosen.

The proposed process was chosen to promote the commitment by both parties (students and companies) in the development of project work, by creating a way of both taking a part in the assignment decision. Another objective was to promote entrepreneurship and communication skills in the students, by leading them into the process of perceiving the client needs, expressed in the initial challenge, creating a viable solution answering these needs and effectively communicating their ideas in the submitted work proposal.

The results of this process were accessed by a survey, conducted after projects conclusion. The results show a generalized approval of the concept, by both students and supervisors. The respondents agree that the process contributed to increase the level of commitment between students and companies, to a better fit between companies and students and that it contributed to a better result in the implementation of the projects

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