Teamwork in Project-Based Learning: *engineering students' perceptions of strengths and weaknesses*

Anabela C. Alves*, Diana Mesquita+, Francisco Moreira* and Sandra Fernandes#

*Department of Production and Systems, School of Engineering, University of Minho Campus of Azurém, 4800-058 Guimarães, Portugal
+ Institute of Education, University of Minho, Campus of Gualtar, 4710-057 Braga, Portugal
#Faculty of Psychology and Education Sciences, University of Coimbra, 3001-802 Coimbra, Portugal

Email: anabela@dps.uminho.pt; diana@dps.uminho.pt; fmoreira@dps.uminho.pt; sandra@fpce.uc.pt

Abstract

This paper explores the importance of the topic of working in teams within Project-Based Learning (PBL) methodology. In the context of the Project-Based Learning methodology at the first year of the Master degree in Industrial Engineering and Management (IEM11_PBL) at the University of Minho-Portugal, a study was conducted to analyze the students' perceptions on teamwork strengths and weaknesses. To attain this goal, a survey was applied to students and small group discussions were carried out to complement the data collection. The survey and the discussion were conducted during a workshop at the end of the semester in the academic year of 2011/2012, and gathered most IEM11_PBL students and teachers. The paper describes some particular details of IEM11_PBL implementation and addresses some specific aspects of the preparation of students for teamwork. Results from the study reveal that most students are keen on PBL learning methodology and as well as on team working. These were substantiated by the recognition that PBL allows the development of key issues for their professional future that were not fully exploited under a different learning methodology. Some examples of strengths of teamwork reported include a higher motivation to learn, students are active within teams and enjoy sharing tasks, teams allow the development of transversal competences, initial challenges faced by students become opportunities for learning and acquiring competences, e.g. on conflict management and having a positive attitude towards problems. Some weaknesses of teamwork within PBL include the formality of meetings and roles within the team and the excessive time and effort required for doing all the teamwork to create the project. Students also perceive that the final grades are not in consonance with the effort done within the project.

Keywords: Teamwork, Project-Based learning, Engineering Education, students perceptions.

1   Introduction

The demands of Bologna Process (European Ministers of Education, 1999; Eurydice, 2010) take into account curricula and pedagogical changes and Higher Education Institutions. The University of Minho, located in the North of Portugal, started to promote workshops and training sessions on Active Learning in the earliest 2000s (with the external support from Peter Powell and Richard Felder) in order to prepare teachers for this new educational paradigm. In this context, Project Based Learning (PBL) was introduced in the academic year of 2004/2005 in the Integrated Master degree in Industrial Engineering and Management (IEM). In this methodology students have to work in teams to develop a project which relates to their professional field. During an entire semester it is expected that students become actively engaged in the learning process. According to the literature, this approach enables decreased drop-out rates, improvements on students' motivation for learning, supports the development of technical and transversal competencies, enables the linking of theory to practice, amongst others factors (Kolmos & Graff, 2007; Bébard et al., 2007; Frenay et al., 2007; Oliveira, 2007; Lima et al., 2007).

When applying PBL teachers and students have to face new challenges and new roles in the learning process. The student roles include autonomy and responsibility on what they learn, how they learn and with whom. The student is in the focal point of the learning process and the teacher becomes a facilitator of that process. Teachers have to be prepared to provide contents, knowledge, tools and give support to students, so that teams are empowered to make their own project decisions. This implies a closer relationship among teachers and students. Within PBL, students have to do much more cognitive and behavioral activities than they normally do in traditional learning. They must be able to lead, decide, manage, plan, adapt and anticipate, since these actions are needed to solve projects. PBL enhances learning environments by giving students the opportunity to reveal creativity, initiative, develop innovative solutions, link theory to actual practice and develop technical and transversal competencies.

PBL provides a set of activities related to management and planning processes that only seems possible in teams (Cinar & Bilgin, 2011). Students have to organize themselves in a team, manage a project, make decisions and find solutions. The activities related to that require an intense and extended interaction between team members throughout the project. According to Powell & Weenk (2003:32), "teamwork takes

probably about 40 to 50% of learning activity". Thus, teamwork emphasizes a continuous interaction between group members concerning the project activities, purposes, knowledge and goals. However, students working together could be a critical issue because it demands much more effort than working individually and, **sometimes, they have to work with who they don't want.** Problems happen during teamwork processes and **aren't easy to solve as conflicts, motivation, communication problems, and so on. And these problems can** compromise the quality of the activities that students are working on and at same time their own learning. In this context, students develop not only technical competencies but also transversal competencies which are quite relevant for their professional practice in engineering, such as communication, problem solving, working with information, leadership, amongst others (Pesches & Reindel, 1998; Moesby, 2005; Becker, 2006; Nair, Patil & Mertova, 2009).

Industrial Engineering and Management PBL projects were introduced on the IEM 1st year 1st semester and on both semesters of the IEM 4th year (Lima et al., 2007, 2009a; 2009b; Alves et al., 2009). The PBL projects were carried out in teams of six to eight members and each team had a tutor during the full project (Alves, Moreira & Sousa, 2007, 2010).

This paper aims to discuss the strengths and weaknesses of teamwork within the 1st year IEM PBL project in **2011/2012 edition (IEM11_PBL). In order to accomplish this objective, the authors describe IEM11_PBL teams'** formation, training and assessment processes, and by reporting on teamwork students perceptions grounded on results from surveys and small group discussion.

2 Context of the Study

Engineering has a fundamental requirement for underpinning understanding and knowledge to the development of new or improved technological apparatus and solutions which improve some aspect of human life. This is translated into products and services which intrinsically hold economic value and can compete in the global marketplace. Key to the development of such products and services is the development of skilled and empowered engineers which, holding deep knowledge and understanding in specific engineering fields, readily understand the wider context of engineering, foster cross-disciplinary challenges and are keen on working with other people.

2.1 Industrial Engineering and Management - first year, first semester project

The Department of Production and Systems (DPS), at the Engineering School of University of Minho-Portugal, has introduced Active and Cooperative Learning in the curriculum of the M.Sc. degree in Industrial Engineering and Management (IEM) by using the Project Based Learning (PBL) methodology since 2004. The PBL learning methodology applied to IEM first year (IEM11_PBL) widely explores teamwork by addressing and developing multidisciplinary semester-wide projects. The class is divided into a number of teams of students which concurrently work out a solution for a proposed challenge. Each team is supported by a tutor. Each team is expected to develop their own vision on the challenge and propose their original solution to it. The teams face several public project presentations, during which lecturers and the other teams of students discuss the choices made. The project themes are open-ended allowing for distinct approaches and solutions. Table 1 presents a comprehensive list of the PBL themes developed so far at IEM11_PBL.

Table 1: IEM11_PBL multidisciplinary projects: editions and themes.

PBL Edition	Project theme
2004/2005	Specification of a production system of biodiesel
2005/2006	Specification of a system for the transformation of forest biomass
2006/2007 S$_1$	Specification of fuel cells production system
2006/2007 S$_2$	Space Tourism
2007/2008	Desalination of sea water
2008/2009	Production of batteries for an electric car; specification of the battery and its production system
2009/2010	Use of organic waste for the production of bio-alcohol
2010/2011	Air$_2$Water – Specification of a portable device for the production of drinking water from air humidity
2011/2012	Clean-up and recovery of crude oil from sea spills

The competencies that students ought to acquire through the development of the team based interdisciplinary project are substantially those specific competencies that students should develop while doing all the project-supporting courses (PSCs) plus transversal competencies (e.g. competencies in management of projects, management of conflicts, oral and written communication, self-regulation of learning, among others). IEM11_PBL holds four PSCs: General Chemistry (GC); Calculus C (CC); Introduction to Industrial Engineering (IIE) and Computer Programming 1 (PC1) (see Figure 1).
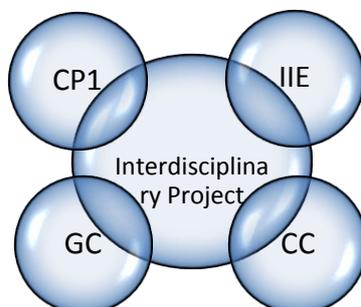

Figure 1: Project based Learning structure in IEM11_PBL: four PSCs.

Student teams are put together during the IEM11_PBL take-off session in the first week of the semester 1 (first year). Therefore, the students hardly know each other at this stage. The rationale beyond the design of the criteria used to set up the teams was intended to:

(1) Provide teams with similar initial technical capabilities to address the project;

(2) Assuring, as much as possible, a uniform distribution of genre among teams.

The PBL coordination team considered relevant for criteria (1) the distribution of members holding prior knowledge background considered relevant for the specific PBL edition. For instance in the *2009/2010* edition - "*Use of organic waste for the production of bio-alcohol*" - chemistry was considered the relevant knowledge background, and therefore the concern was to assure that each team possessed at least one member coming from that area of study in the secondary school. After guaranteeing existence of specific knowledge in all teams, the aim shifted to levelling the number of members holding it. Criteria (2) attempted to level the distribution of genre among all teams since the IEM newcomers genre proportion varies annually. This is targeted at assuring that no team is single genre (although, such a case has previously occurred in one edition of IEM11_PBL, apparently without unwanted consequences). The class is normally divided into 6 teams of 6 to 8 students each. Each team tackles the PBL challenge throughout the semester. Table 2 illustrates the milestones for the teams during semester 1.

Table 2: Milestones for IEM11_PBL (9th edition, 2010/2011)

Milestone	Date	Requisite
1	Week 2	Pilot Project presentation
2	Week 5	Project progress presentation
3	Week 8	Intermediate report (max. 20 pages)
4	Week 9	Extended tutorial
5	Week 12	Preliminary version of the final report (max. 50 pages)
6	Week 17	Final report (max. 60 pages); prototype delivery
7	Week 18	Final exam; final presentation; discussion and poster delivery

After team formation a tutor is randomly assigned to each team. A group of teachers from the DPS has been steadily tutoring the teams during most IEM11_PBL editions. Tutors were occasionally recruited from other departments, always on a voluntary scheme. These were mainly lecturers from PSCs who wished to try out the tutoring role. The tutors from DPS were PSC lecturers as well as non-PSC lecturers. In one PBL edition a visiting professor was also tutor of a team during a semester. Tutors were most of the times responsible for one team only (in eight out of nine editions). Only in one occasion the same tutor coordinated the works of two teams simultaneously (in 2011/2012 edition).

2.2 Preparing students for teamwork in PBL
To prepare students for teamwork in IEM11_PBL a number of different activities are put in place at various stages of development of the project: 1. hands-on training sessions; 2. teamwork as a theme of a contents

subject; 3. the role of the tutor; and 4. peer assessment mechanism. These activities are described in the following sections.

2.2.1   Hands-on training sessions

The 1st week of the project is quite intense for the students because it is the beginning of their contact with the university, new colleagues, new teachers, and in some cases, a new town as well. For that reason, students need an extraordinary support during this period, in order to develop the Pilot Project and also to prepare the public presentation at the end of the first week.

The hands-on training session intends to create an opportunity for students to start to interact with each other like a team. A set of activities are planned by two researchers from the Education Sciences field. These activities are different in every edition, but the goal is always the same: to get the students working in the teams of the project, using fun challenges with a specific goal. For instance: several magazines and newspapers are provided to teams and during 30 minutes they must prepare a poster with images and words that show their team´s identity and what the team wants to achieve with the project. Then, teams have to do a short oral presentation. All the activities are complemented with questions related to teamwork, namely the key issues that teams go through during the project: problems with time management, conflicts, motivation, and so on.

An important message that is given to students in these sessions focus on the idea that the project is an important moment in their academic trajectory route, and that they must be able to take advantage of the opportunity to develop competences that are important to engineering practice.

2.2.2   Teamwork as a theme of a contents subject

After the hands-on training session, some classes of the IIE course unit focus on teamwork issues: team work *vs* group work differences and definition; team management as a requirement for production management; transversal competences (project management, teamwork, interpersonal relationship and development, communication skills); team formation and development stages (forming, storming, norming, performing and adjourning); working in teams and the need of hard and soft skills; Yerkes – Dodson (1908) Law; team work communication; the communicational profile of each individual (passive, manipulator, aggressive and assertive).

Tools to support effective team meetings and work are also addressed, these includes: brainstorming, **catastrophic strategy, "advocate angel" strategy, mental cards and others. Ishikawa diagrams, forces and** weaknesses diagrams, affinity diagrams, pondered vote, 5M1E (Man, Machine, Material, Method, Measurement and Environment) checklists (Maynard, 1971), and SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) tools were also addressed. These are targeted at organizing and classifying ideas **from brainstorming exercises. Group phenomena awareness is raised and discussed, these include: "Lambs", the "Cockfighting" and the "Silence revolt". Tools for** identification and analysis of problems, such as 5W2H (Who, What, Why, When, Where, How, How much/long), 5Why technique (Suzaki, 1993), and problem solving methodologies such as PDCA cycle (Plan, Do, Check, Act), A3 tool, DMAIC cycle (Define, Measure, Analyze, Improve, Control) and 8D (Duret & Pillet, 2009) are also introduced and described.

It is expected that the teams use a number of such tools at some stage of development of the project. Previous projects have confirmed that a number of teams have freely chosen and conveniently applied a number of different tools to support decision making and teamwork activities. For example: (1) brainstorming technique **has been applied to select the company's name at an initial project design stage; (2)** the forces and weaknesses diagram was used to select the geographical location for the company.

2.2.3   The role of tutor

The tutoring process in IME11_PBL is commonly developed by PSC lecturers, and not as often by non-PSC lecturers (Alves, Moreira & Sousa, 2007; 2010). Each tutor is responsible for a team of 6 to 8 students that is shaped at project start. Students are free to choose their teammates, bearing in mind a couple of rules to assure teams uniformity, i.e. normally in terms of gender and previous technical expertise. The IME11_PBL tutoring process normally involves a one hour weekly meeting between the tutor and his/her team. During this meeting, the tutor discusses with the students several teamwork issues and project management issues. **According to Powell (2004), the tutors' role should not be to supply answers but instead to give clues**, so that the team tackles the problems and develops the most appropriate solutions by itself. Tutorial meetings are held in the team-assigned project room, at a pre-scheduled date and time. Tutorial meetings are not included in student's timetable, they are held in extra-curricular moments.

2.2.4 Peer assessment mechanism

IEM11_PBL allows team members to evaluate their individual contribution to the overall project progress and project outcomes during the semester. This is targeted at pursuing and rewarding excellence by immediate peer acknowledgement. This mechanism also identifies early stage underperformance, allowing for self-regulation and compensation mechanisms. It gears on an individual self-improvement continuous process towards improved teamwork, ultimately leading to excelled results.

Within a given team, students individually evaluate each other's contribution using a predefined criteria. The quantitative result is the individual **team member "Correction Factor" (CF).** This factor will dictate the individual grade attained by each team member given the project grade attained by the team. At the end of semester the project team grade is multiplied by CF resulting in individual grades. Within a team CF average his equal to 1.0, i.e. the average of individual grades is equal to the team grade. Individual CFs can be obtained by averaging all the results from the peer assessments done along the semester.

However, when designing peer assessment strategies, a set of issues need to be discussed and clarified by both teachers and students. What form will peer assessment take and how will students keep track of their performance, are important questions that need to be addressed before the project starts. Assessments can be individual or collective, anonymous or face-to face, based on individual comments on each student or a single comment arrived at by consensus. During this phase of decision making, students should play an active **role on the process, as this encourages students' responsibility on the assessment process and further** results. However, issues regarding assessment reliability are sometimes questioned, as there is always the risk that students allow friendship to influence their perceptions and assessments.

3 Methodology

This paper intends to explore the strengths and weaknesses **of teamwork, according to the students'** perceptions from 1st year of IEM project of 2011/2012 edition. These perceptions were collected by an individual survey and in small group open discussions in a workshop organized at the end of the semester. The workshop was intended to discuss some topics related to the PBL, in order to improve next editions and also to reinforce the positive dimensions pointed out by the students. The results are shared among the team of faculty staff.

The survey was applied at the beginning of the workshop and this paper is focused on the results related to teamwork indicators. The overview of the survey presents six dimensions: 1. project theme; 2. learning and competences; 3. teamwork; 4. teachers and tutors role; 5. assessment; and 6. PBL as a learning methodology. There are a total of 46 statements where students must select from a scale of 1 (totally disagree) to 5 (totally agree). At the end, students have the opportunity to point out positive and negative topics, and also to give suggestions to improve the project experience.

Small group discussions with students were organized after the survey was completed. This discussion aimed **at collecting students' opinions in a more open manner. These discussions were facilitated by the educational** researchers who participated in the IME11_PBL coordination´s team. Some of the topics discussed included the project theme, the assessment method and the PBL as a learning methodology.

As previously mentioned, the study is focused on teamwork and the results of the survey were selected according to this category: the motivation for learning, the importance of formal roles inside the team, the relevance of interpersonal skills, the task split to manage the project, the impact of the assessment, amongst others.

Therefore, the methodology uses a quantitative and a qualitative instrument to collect the opinions and perceptions of the IEM11_PBL students to give them the opportunity, by writing or discussing in an open and informal environment, to express themselves without fear of repressions.

4 Students' perceptions: results and analysis

In this section, results from the survey applied to IEM11_PBL students are presented and followed by discussion, pointing out the strengths and weaknesses of teamwork in IEM11_PBL. Our attention focuses on the dimensions related to: 1. PBL as a learning methodology, 2. teamwork, and 3. assessment in PBL, since the items used in each are related with teamwork as a transversal skill developed in the PBL methodology.

The dimension of "Student learning in PBL and the development of skills" intends to evaluate the perceptions of students related to the PBL as a learning methodology and the results of the survey are presented in Figure 2, showing the average obtained for each indicator used in this dimension.
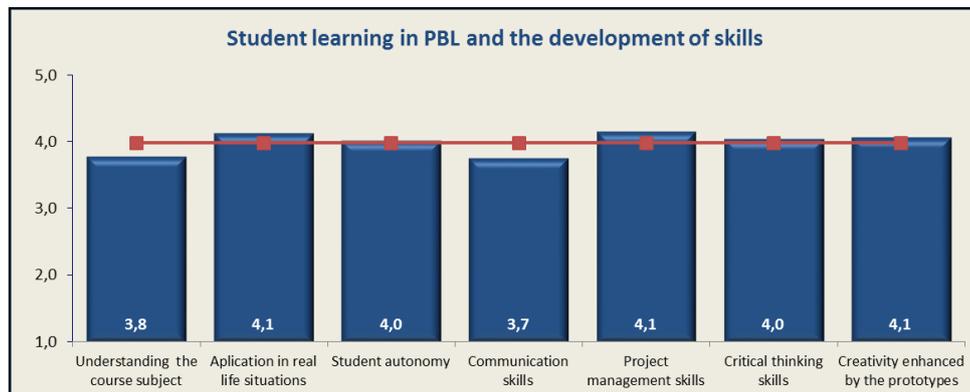

Figure 2. Results of the survey for the dimension **"Student learning in PBL and the development of skills"**

Another important dimension analyzed is teamwork in itself. Figure 3 presents the results from the dimension "Teamwork" of the survey and the average obtained for each indicator considered in this dimension.
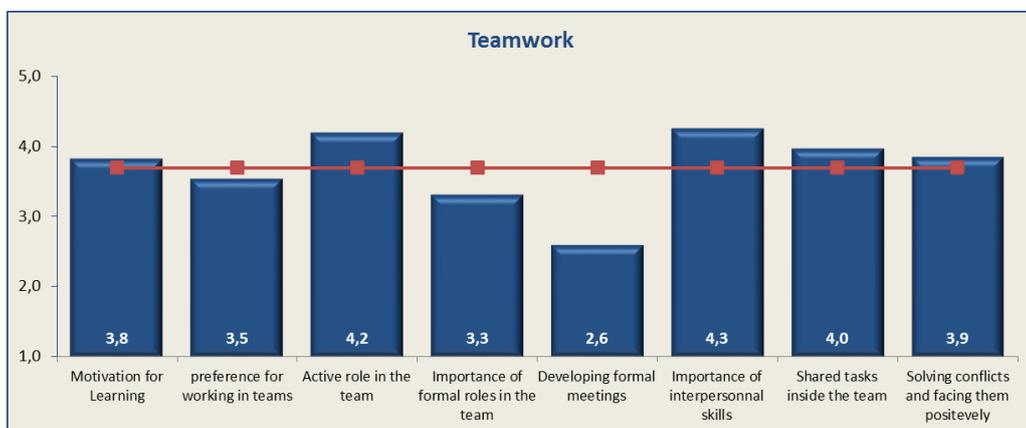

Figure 3. **Results of the survey for the dimension "Teamwork"**

Figure 4 shows the results of the dimension related to "Student assessment in PBL", presenting ten items that were used to collect the opinion of students on this dimension.
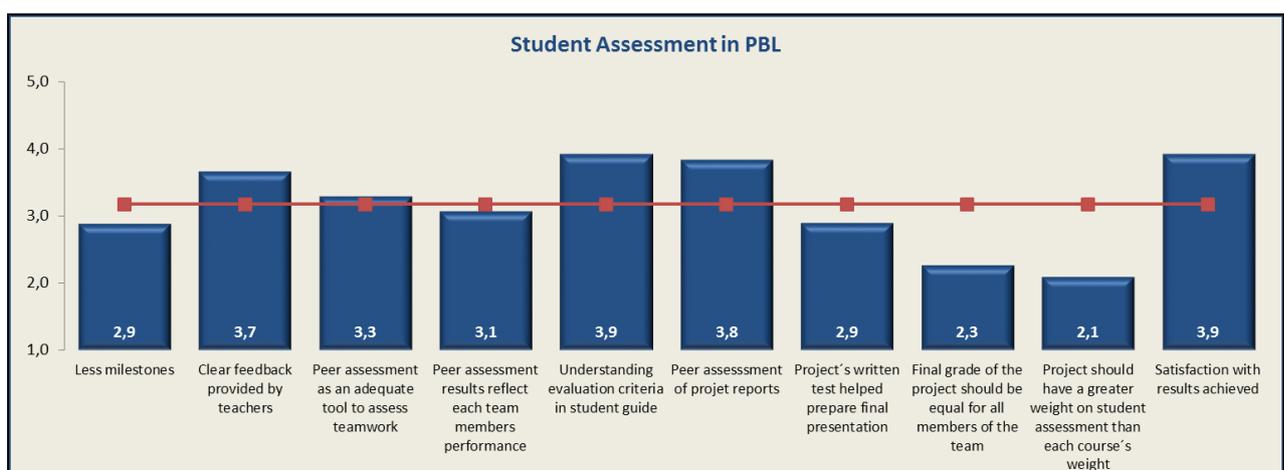

Figure 4. **Results of the survey for the dimension "Student assessment in PBL"**

In the small group discussions, two dimensions of teamwork **were considered: (1) "PBL as a learning methodology"; and (2) "Student assessment in PBL". The main findings are analyzed acco**rding to the main strengths and weaknesses identified by students in regard to teamwork.

4.1 Strengths of teamwork in PBL

In general, students are quite positive in regard to the benefits of PBL as a learning methodology, as seen in Figure 2, which analyses the dimension "student learning in PBL and the development of skills". An overall **analysis of students' answers showed a high average of students classifications in regard to the dimensions** included in the survey. These results reveal that students are quite positive about PBL as a learning methodology. They argue that PBL has a strong contribution to the development of important skills for students´ future career as engineers, such as communication skills, project management, critical thinking and creativity. Besides these competencies, students highlight that the project allows a better understanding of course contents, as students are able to apply them in real life situation. In this sense, there is a link between theory and practice and interdisciplinary is fostered within the curriculum.

Figure 3, in turn, presents the results from the item "Teamwork" of the survey. In this case, there is a greater variation in results, when compared to the previous category analyzed. This has obviously to do with what is expected by the PBL coordination team that students should do or manage, while working in teams. Almost all items received a good average indicating the importance that students give to teamwork dimension. It seems that most of the students believed in their active role in the team-working and in its importance for their professional future of developing a skill of interpersonal relationships. They also gave a good score to shared task and knowledge with the colleagues, another important item in the teamwork.

One of the major assets that influence students' satisfaction is the assessment method and the final grades achieved in the project (Figure 4 above). Previous research suggests that assessment practices in PBL enhance deep learning, by linking theory to practice to solve real life problems and by providing students with several opportunities with feedback which enables them to improve their work (Fernandes, Flores & Lima, 2012). This **is corroborated by the results of items "feedback provided by teachers" and "satisfaction** with the **results achieved" in Figure 4.**

Peer assessment, presented in Figure 4 above, is an important issue in PBL as teammates should play an active role on the assessment process and this also encourages team members**' responsibility on the** assessment process and further results. Data collected in several PBL editions demonstrated that peer assessment had a positive impact on student engagement, as students reported working harder in the period after assessment results were presented (Fernandes et al., 2009a). Results from the survey applied to students in this study also confirm this, as seen in Figure 4. Students consider very positive the exercise of assessing the project report of a different team other than their own. This activity allows students to reflect on their own work and develop competencies in critical thinking and providing feedback.

Additionally, another important asset of teamwork in PBL is the tutor´s role (not in the figures presented). The tutor plays an important role in monitoring and providing feedback to students, especially when discussing peer assessment processes, discussed above. Peer assessment has been very useful to help solve conflicts and problems amongst team members. Previous findings from individual interviews held to tutors involved in PBL experiences point out the benefits of peer assessment for identifying problems within the team or poor performance of a team member (Alves, Moreira & Sousa, 2007; Veiga Simão et al., 2008). Tutors recognize that it is easier to confront students when there is formal evidence that something in the team is not going well than when based on their own intuition.

In general, findings from these small group discussions were in accordance with the results obtained in the survey, as it is possible to see in the Table 3 which summarizes the advantages pointed out by students in regard to PBL as a learning methodology. .

Table 3: Advantages of PBL as a learning methodology based on student group discussion

PBL as a Learning Methodology	
Advantages	1. teamwork 2. time management 3. working to achieve a certain goal 4. development of social competencies 5. project dynamic

4.2 Weaknesses of teamwork in PBL

One of the items that stand out when looking at the results of Figure 3 above is the low average obtained in the items related to the formal meetings and roles played by students in the team. The formal roles and meetings are subjects which are discussed with students in the hands-on training session carried out at the

beginning of the semester. However, students seem not to understand or recognize the importance of adopting these formal roles throughout the project, arguing that informal strategies are preferred most of the times. This attitude can eventually be explained by the fact that students see each other daily and work on the project together, which can make these formal meetings and roles unnecessary. Further reflection on this topic should be promoted by the coordination team and possible changes in concern to strategies other than formal meetings should be suggested to support teamwork.

From Figure 4, it is also possible to see that the assessment method of PBL reveals a set of constraints with re**gard to students' learning process and outcomes**. One of these constraints of this innovative approach to learning is the heavy workload which it entails. After they have given a lot of time and effort to the project, students have high expectations on the assessment results. They expect a high final grade as a reasonable reward for their hard work. Student satisfaction is somehow influenced by this expectation, as students consider, at the end of the project, that they get a relatively low return in terms of grades, compared to non PBL approaches, where their effort is much lower. This could be related with the poor score given to the item **"project should have a greater weight on student grade".** However, a study based on the analysis of academic results of PBL and non PBL students showed that this assumption is not true (Fernandes et al., 2009b). Findings from this study showed that PBL students achieved, on average, better results than the non PBL students at all courses and for the three academic years analysed.

Figure 4 also shows low averages in the **"project final test as a help in the final presentation" and "final grade of project must be equal for all members of team"**. Project final test is an individual written test at the end of the semester that was designed according to the specific goals and outcomes reached by each team and intended to provide evidence on student´s individual accountability. The overall goal is to assess the understanding and application of knowledge on the project, distinguishing the team members about their knowledge of the project and to avoid partial knowledge. Normally, this test creates misunderstandings and dissatisfaction amongst students, besides the fact that they usually don´t achieve very good grades. This could indicate that the objective is not achieved, or at least, the students divide tasks and do not worry about learning and sharing the knowledge. A low average in regard to the final grade of project being equal for all members could mean that the students know that it is unfair because they did not work equally.

Additionally, and about the dimension of the "Tutor role", the teams average concerning the tutor role indicates that they considered that the tutor should be a teacher of a course unit. This could show that the **tutor role is not very well understood by the students'** teams as they expect some technical support in the project. **Besides this, a possible disadvantage of peer assessment processes is that it may increase tutors'** workload in terms of briefing students about the process and ensuring the criteria are explicit and clear.

As disadvantages resulted from the group discussions about the PBL as a learning methodology, the students indicated the following: 1. time required for the projects, 2. the need/difficulty to integrate the contents in the project and 3. effort put in the project and its impact in final grades.

4.3 Suggestions for improvement

From Figures 2, 3 and 4 it is possible to conclude that the dimension of student assessment in PBL seems more debilitated, with some aspects requiring greater attention by the coordination team. This is not a novelty and throughout the last few years, some attempts have been made to improve the assessment method and contribute to greater student satisfaction in PBL. For the coordination team, the current assessment methods disclosed the need to clarify assessment criteria, the need to assure individual accountability of students in teamwork and also the importance of opportunities for student self-assessment and development of critical thinking and evaluation skills. In order to respond to these needs, changes have been introduced in the assessment process, such as the implementation of an individual written test at the end of the semester, with the overall goal to assess the understanding and application of knowledge on the project; rubrics to assess oral presentations and project reports, facilitating a common understanding of assessment criteria by lecturers and tutors; and also peer review processes based on the assessment of other teams project reports by students, allowing them to learn from each other and play a more active role in the assessment process.

In a continuous improvement perspective, the coordination team is continuously reflecting on the process together with the main intervenient and clients of this process, the students. So, in this edition, the suggestions given by the students for improvement PBL as a learning methodology are in Table 4.

Table 4: Suggestions for improvement from group discussion of PBL as a learning methodology

PBL as a Learning Methodology	
Suggestions for Improvement	1. PBL should be held in an industry in order to see how it works 2. criteria for peer assessment should be revised and tutor should participate in student assessment 3. all tutors should be lecturers of the course subjects 4. better selection of tutors and control of the work each one develop

5   Final remarks

This paper explored the strengths and weaknesses of teamwork within Project-Based Learning methodology in the M.Sc. degree in Industrial Engineering and Management (IEM11_PBL) at University of Minho, Portugal. The study is grounded on students' perceptions from the 1st year of IEM11_PBL of 2011/2012 edition, collected at the end of the semester using individual surveys and small group open discussions.

Results from the survey show that students have a positive opinion on the use of PBL as a learning methodology. Students acknowledge that PBL promotes the development of important competencies for their future which encompass not only a better understanding of real-life application of theoretical concepts and course contents, but also a number of key transversal competencies, developed and improved throughout the semester by a number of project activities, namely the ones involved in team working.

PBL teamwork survey specific results point out that students give importance to teamwork and prefer to learn by working in teams. They acknowledge their active role within the team, attribute a special relevance on teamwork for the development of interpersonal skills, and recognize it as a learning process for solving conflicts and holding a positive attitude towards its resolution. Students were also positive about teamwork relating the sharing of tasks and higher motivation to learn. Small group discussions broadly confirmed the survey results. Additionally, students consider the tutor as a valuable asset of the team and agree that the final individual grade should indeed reflect the global contribution of individuals on both the overall process and project outcomes quality. Team formation was a factor pointed out by students as influencing teamwork and group performance.

The main weaknesses of teamwork within PBL, revealed by the survey, point out that the formal roles of team members within meetings, along with the need for such formal meetings are not important – informal meetings are the preferred meeting format. Students also reveal that there are too much milestones; the high effort required by the team is not in line with the weight of the project in individual grades. The small group discussions reinforced the perceptions that PBL is a time-consuming learning methodology, requires a heavy effort that is not always reflected in the final grades.

Future work should focus on promoting reflections on PBL requirements for formal meetings and strategies for wider adoption within teams. Further discussion on the need for PBL teamwork heavy workload seems plausible along with reflections on project dimension *vs* assessment system. A PBL tutor-based strategy is required to clearly conform teams expectations to those of the actual tutor role. The need for an improved balance between PSC assessment activities and project´s milestones seems reasonable. This requires improvements for the design and planning of course units, especially for those joining PBL projects for the first time.

Acknowledgment

References

Alves, A. C., Moreira, F. & Sousa, R. (2007) **"O Papel dos Tutores na aprendizagem baseada em projectos: três anos de experiência na Escola de Engenharia da Universidade do Minho" In Actas do XI Congreso Internacional Galego**-Português de Psicopedagoxia, 19-21 de Setembro, A Coruna

Alves, A. C., Moreir**a, F. & Sousa, R. (2010) "Aprendizagem baseada em Projectos Interdisciplinares em Engenharia Industrial: dissimilitudes de tutoria entre o início e o final do curso", Proceedings of Second Ibero**-American of Symposium on Project Approaches in Engineering Education (PAEE2010), (Eds.) N. van Hattum-Janssen, R. M. Lima, D. Carvalho, Research Centre in Education (CiEd) University of Minho and Department of Production and Systems School of Engineering of University of Minho, ISBN: 978-972-8746-86-5, pp. 133-138

Alves, A., Moreira, F., Sousa, R. & Lima, R. M. (2009). Projectos para a Aprendizagem na Engenharia e Gestão Industrial. In: Livro de Actas do X Congresso Internacional Galego-Português de Psicopedagogia., (Eds.) Cied-Universidade do Minho, Braga-Portugal, 9-11 Setembro 2009, Universidade do Minho, pp. 3360-3375 (CD-ROM), ISBN 978-972-8746-71-1.

Becker, F. (2006). Globalization, curricula reform and the consequences for engineers working in an international company. European Journal of Engineering Education, (31)3, 261-272.

Bédard, D., Louis, R., Bélisle, M. & Viau, R. (2007). Project-based and Problem-based Learning in Engineering at the **University of Sherbrooke: Impact on Students' and Teachers' Perceptions. In Erik de Graaff & Anette Kolmos (Eds).**

Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering. Rotterdam: Sense Publishers. pp. 109-129.

Cinar, Y. & Bilgin, A. (2011). Peer Assessment for undergraduate Teamwork Projects in Petroleum Engineering. International Journal of Engineering Education, 27(2), pp. 310-322.

Duret, D. & Pillet, M. (2009) "Qualidade na produção: da ISO 9000 ao Seis Sigma" Lidel – Edições técnicas, Lda.

European Ministers of Education (1999). The Bologna Declaration of 19 June 1999. The European Higher Education Area.

Eurydice (2010). Focus on Higher Education in Europe 2010: The Impact of the Bologna Process. Education, Audiovisual and Culture Executive Agency (EACEA P9 Eurydice).

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, pp.163-178.

Fernandes, S., Mesquita, D., Lima, R. M., Faria, A., Fernandes A. & Ribeiro, M. (2009a). The Impact of Peer Assessment on Teamwork and Student Evaluation: A case study with Engineering Students In U. Domínguez (Ed.). *Proceedings of the International Symposium on Innovation and Assessment of Engineering Curricula*, Curriculum Development Working Group (CDWG), European Society for Engineering Education (SEFI). 15-17 May 2009, Valladolid, Spain. ISBN: 978-84-692-2864-7

Fernandes, S., Lima, R. M., Cardoso, E., Leão, C. & Flores, M. A. (2009b). An Academic Results Analysis of a First Year Interdisciplinary Project Approach to Industrial and Management Engineering Education. In D. Carvalho, N. van Hattum & R. M. Lima (Eds.). *Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education* **(PAEE'2009). 21**-22 July 2009, Guimarães, Portugal. pp.37-43. ISBN: 978-972-8746-74-2.

Frenay, M., Galand, B., Milgrom, E. & Raucent, B. (2007). Project- and Problem-Based Learning in the Engineering Curriculum at the University of Lovain. In Erik de Graaff & Anette Kolmos (Eds). Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering. (pp. 93-108). Rotterdam: Sense Publishers..

Galand, B., Raucent, B. & Frenay, M. (2010). Engineering Students' Self Regulation, Study Strategies and Motivational Believes in Traditional and Project-Based Curricula. International Journal of Engineering Education, 26:3, 523-534.

Kolmos, A. & Graaff, de E.(2007). The Process of Changing to PBL. In Erik de Graaff & Anette Kolmos (Eds). Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering. Rotterdam: Sense Publishers. pp. 31-43.

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., Carvalho, D., Sousa, R. M. & Alves, A. (2009a). Management of Interdisciplinary Project Approaches in Engineering Education: a Case Study. In: Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE2009), Eds. Dinis Carvalho, Natascha van Hattum-Janssen and Rui M. Lima, Guimarães, ISBN: 978-972-8746-74-2, pp. 149-156.

Lima, R. M., Fernandes, S., Mesquita, D. & Sousa, R. M. (2009b). Learning Industrial Management and Engineering in Interaction with Industry. In: Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE2009), Eds. Dinis Carvalho, Natascha van Hattum-Janssen and Rui M. Lima, Guimarães, ISBN: 978-972-8746-74-2, pp. 219-227.

Lima, R., 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.

Mesquita, D., Alves, A., Fernandes, S., Moreira, F. & Lima, Rui M. (2009). A First Year and First Semester Project-Led Engineering Education Approach. In: Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education (P**AEE '2009), Eds.** Dinis Carvalho, Natascha van Hattum-Janssen and Rui M. Lima, Guimarães-Portugal, (CD-ROM). ISBN: 978-972-8746-74-2, pp.181-189.

Moesby, E. (2005). Curriculum Development for Project-Oriented and Problem-Based Learning (POPBL) with Emphasis on Personal Skills and Abilities. Global Journal of Engineering Education, (9)2, 121-128.

Mynard, H. B. (1971). Industrial Engineering Handbook. McGraw- Hill, New York

Nair, C., Patil, A. & Mertova, P. (2009). Re-engineering graduate skills – a case study. European Journal of Engineering Education, (34)2, 131-139.

Oliveira, J. M. (2007). Project-Based Learning in Engineering: The Águeda Experience. In Erik de Graaff & Anette Kolmos (Eds.) Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering. Rotterdam: Sense Publishers. pp. 169-180.

Pesches, K. & Reindel, E. (1998). Project-Oriented Engineering Education to Improve Key Competencies. Global Journal of Engineering Education, (2)2, 181-186.

Powell, P. C. & Weenk, W. (2003). Project-Led Engineering Education. Utrecht: Lemma.

Powell, P. C. (2004). Assessment of team-based projects in project-led education. European Journal of Engineering Education, 29(2), 221-230.

Veiga Simão, A. M., Flores, M. A., Fernandes, S. & Figueira, C. (2008). Tutoria no Ensino Superior. Concepções e práticas. *Sísifo. Revista de Ciências da Educação*, 7, pp. 75-88. Consultado em Janeiro.

Suzaki, K. (1993). The new shop-floor management: empowering people for continuous improvement. The Free Press, Appendix 7.2

INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

**Organizing and Managing
Project Based Learning**

INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Organizing and Managing
Project Based Learning

Natascha van Hattum-Janssen
Rui M. Lima
Dinis Carvalho
Luiz Carlos de Campos

Pontifícia Universidade Católica de São Paulo, Brazil
26-27 July 2012