International Journal of Engineering Education Vol. 33, No. 3, pp. 1000–1017, 2017
Printed in Great Britain

0949-149X/91 $3.00+0.00

Motivational Factors to Consider when Introducing Problem-Based Learning in Engineering Education Courses*

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Problem-Based Learning (PBL) has become more popular in higher education over the past several years. It has proven to be effective in engineering education to increase students' motivation and the acquisition of skills required by the labour market and today's society. However, even when PBL is gradually introduced at an institution alongside traditional teaching, it is not perceived by students as an easy way to learn, especially when ill-structured, real problems are first introduced. Students can feel stressed, often because of their lack of both skills and previous knowledge, and they often prefer to focus their efforts on the final result and on passing their exams rather than the problem-solving process. To identify the difficulties that students have during PBL and to re-design instruction to increase students' motivation, this study used the MUSIC® Model of Motivation as a conceptual framework. This paper analyses students' motivation when PBL is introduced in a traditional-teaching institution, and discusses the main adjustments needed to increase students' motivation, engagement, and learning.

Keywords: problem-based learning; MUSIC Model of Motivation; motivating students; learner-centred approaches; engineering education

1. Introduction

The new structure imposed in Europe by the Bologna Process has led to major changes in higher education institutions. The Bologna Process created the European Higher Education Area (EHEA), which is aimed at promoting the European recognition of qualifications, the mobility of students, teachers and researchers, and acquisition of lifelong learning skills and competences [1]. The EHEA necessitates the use of new teaching methods at the expense of traditional lecture-based teaching, the continuous assessment of the students, and their participation as active learners. In other words, it promotes the role of students as controllers of their learning process, and limits the role of teachers as mere transmitters of knowledge [2]. Consequently, Spanish universities are facing the challenge of adapting their curricula to the exigencies of EHEA. This circumstance has added to a financial crisis situation in Spain [3] and to the competition between an increasing number of universities in the country. In 2015, there were a total of 50 public and 33 private higher education institutions in Spain [4].

In addition, the different national regulations have not solved the structural difficulties of the students entering the university. In the specific case of the Canary Islands, the secondary education institutions still had a 23.8% dropout rate in 2014 [5]. Besides, the Canarian secondary school students had the second worst scores on the Program for International Students Assessment (PISA) in 2012 as compared to the rest of Spain, which is equivalent to one year below the average of OECD countries [6].

In Spain, the students coming from secondary school have to pass a general exam, which is valued from 1 to 10 points. After that, students can obtain up to 4 additional points by passing a specific exam. The minimum score required to access the higher education system is established by each university for each degree. The average score of many (73.4%) of the students enrolled in engineering degrees in Spain in 2014–15 was between 5 and 6.5 points. Only 6.2% of these students had a score between 10 and 14 points [6]. In the case of the students enrolled in engineering degrees at our institution (University of La Laguna, Canary Islands, Spain), the average score in was 5.897 points in the general exam [7], which assesses the students' knowledge in basic subjects related to engineering. The authors have observed that the low profile of the students enrolled in these degrees has a negative impact in their

* Accepted 4 December 2016.

performance during their first university courses. Furthermore, because the students' courses prior entering higher education are principally focused on passing these exams, less emphasis can be placed on developing problem solving and transferable skills.

On top of that, the quality assurance in the higher education Spanish agency (ANECA) noted in 2009 that most of the higher education students in Spain presented attitude difficulties [8]. This weakness is linked with the low capacity of putting the required effort into their school work. ANECA also emphasizes that the requirements of the labour market are linked with a society that is changing quickly, which has a direct influence on the possibilities for success of the students exiting the university. Moreover, the bases of EHEA involves innovation, competitiveness, employability, and the local labour market [9], but in the case of Spain, professional associations have reported that recent university graduates appear to have a lower educational levels than older pre-Bologna graduates [10]. In fact, the Bologna Process adaptations that were performed involved subjects and content, rather than using intended learning outcomes as a starting point; perhaps this is because the traditional orientation of faculty staff [11].

A change in strategies may improve the efficacy of the learning process, including the acquisition of the skills required by the society, the labour market, and the future challenges that our students will have to face in the near future. The Strategic Plan of the University of La Laguna endorses the promotion of students' creativity, critical thinking, and problem solving [12]. These ideas are in opposition to the traditional teaching model followed by many universities, consisting of lectures with traditional problems and practices. In fact, our institution has a traditional learning approach, which is reflected in our infrastructure and spaces that have not been designed for teamwork.

In an initiative to face these difficulties with a non-traditional approach at the University of La Laguna, the authors have adopted Problem-Based Learning (PBL). This way of learning has proven to be effective in decreasing the dropout rate [13], increasing students' motivation [14], improving the integration of students' knowledge [15], and easing the acquisition of long-life learning skills [16], and also hard and soft skills [17, 18]. The integration of PBL in the curricula can affect all educational stakeholders, including students [19, 20]. Yet, students who are used to traditional teacher-centred learning may encounter difficulties when trying to adapt to PBL [14]. Although the integration of PBL in isolated subjects may not be an ideal solution, it is a feasible solution when other faculty are opposed to the use of PBL [21], which can be a common circumstance in traditional institutions. In this regard, integrating PBL may interfere with other subjects and can present additional difficulties to students. As such, our team has focused on testing several PBL strategies in order to gain experience in PBL and to observe students' reactions; and furthermore, to support our process of switching to a PBL approach that uses scientific evidence that may be used to inform others, including institutional leaders, of the strengths and weaknesses of the PBL approach. With regards to overcoming other difficulties (e.g., financial support, proper infrastructures, and organisational facilities), we believe that an increase in students' acceptance of PBL is the first step towards implementing active learning to face real-world, higher education challenges, but it requires a deep understanding of the motivation principles that may engage or frustrate the students.

2. The link between PBL and the MUSIC Model of Motivation

Team-work and the problem-solving process tend to increase students' motivation [22]. But motivation does not increase simply by exposing the students to a complex problem. Students need support from the very first stages of PBL [23], and this makes it necessary to understand the principles of PBL and the aspects that promote or undermine students' motivation.

2.1 Problem-Based Learning

At its core, Problem-Based Learning (PBL) introduces students to an ill-structured problem that does not have a direct or trivial solution. This supposes a challenge to the students, and requires the acquisition of knowledge and skills, and the development of a strategy to reach a solution. Because PBL requires students to use their knowledge, skills, and strategies, it has been considered as an alternative for engineering education. A related approach, *Project*-Based Learning, has a differential treatment [15, 24], even though both approaches have the same origin. In fact, Barrows [25] did not consider PBL as a unique method, but instead, as a set of unlimited alternatives chosen for a selected learning goal. By following this idea, the problem should be designed to drive and to contextualize the learning process, and thus, motivating the students. This is why the practice of PBL, even case-oriented as developed at McMaster University, or project-oriented like at Aalborg University, both share the same theoretical principles [26].

As a consequence, the differences between problem-based and project-based learning models are not in how the students learn, but in the definition of

the problem and the process by which students reach any of the possible solutions. In engineering, the problem can be very complex and transversal, and it can require a longer time, even years, to solve. De Graaff and Kolmos [19] highlight the main difference between problem-based and project-based approaches: project-based learning requires a finished product or a deliverable, which represents something to be assessed.

The strategies that have been used in the literature to introduce PBL in engineering education vary. Some authors suggest PBL as a partial strategy that can be implemented during the first years of college [27]. Meanwhile, others prefer the adaptability of a mixed approach, combining projects and conventional courses [13], or recommend integrating projects and/or cases during the entire curriculum [28]. However, the adoption of PBL should be gradual, and requires, firstly, that the students and the academic staff get used to the difficulties of adopting PBL for first time [29, 30].

2.2 The MUSIC Model of Motivation

The field of motivation is comprised of many mini-theories, such as attribution theory [31], expectancy-value theory [32], goal orientation theory [33], self-determination theory, [34], social cognitive theory [35], interest theories (e.g., [36]), self-concept theory [37], and many others. Although teaching implications can be derived from all of these theories, none of these claims to be an all-encompassing motivation theory for students in academic courses. As a result, instructors must examine the implications from all of these theories when designing instruction. Because this can be an overwhelming task for instructors unfamiliar with the research and jargon in the field of motivation, Jones [38, 39] developed the MUSIC® Model of Motivation (MUSIC model) [38, 39] to help instructors to design instruction in ways that are consistent with current research and theories in motivation. MUSIC is an acronym that is used to remember the five key principles of the model, which relate to the words eMpowerment, Usefulness, Success, Interest, and Caring. The principles of the MUSIC model are that the instructor needs to ensure that students: (a) feel *empowered* by having the ability to make decisions about some aspects of their learning, (b) understand why what they are learning is *useful* for their short or long-term goals, (c) believe that they can *succeed* if they put forth the effort required, (d) are *interested* in the content and instructional activities, and (e) believe that the instructor and others in the learning environment *care* about their learning and about them as a person [38, 39]. Studies have shown that the five MUSIC components are correlated, yet distinct; for example, in a variety of college courses [40], including engineering courses (e.g., [41–43]).

The MUSIC model can be used as a framework to examine students' motivational experiences during or at the end of a course (e.g., [43, 44]). For example, researchers used the MUSIC model to find motivating opportunities that occurred during an engineering capstone course that incorporated PBL [45]. Doing so allowed them to identify instructional elements related to the course project design, group experience, and project advisor that were critical for instructors to consider when designing instruction. The results obtained by examining instruction using the MUSIC model can then be used to re-design or make minor adjustments to instruction in ways that can increase students' motivation, engagement, and learning. We chose to use the MUSIC model in the present study because: (a) it is a multidimensional model that was designed specifically to help instructors implement motivation strategies, (b) researchers have provided validity evidence for the use of the MUSIC model in engineering courses, and (c) it is possible to assess students' motivation-related beliefs related to each of the MUSIC model components.

3. Research methodology

The impact of PBL on students was analysed quantitatively for each of the MUSIC model components, as well as qualitatively by comparing the students' and teachers' perceptions of the course. The following sections summarize the design and organization of the experiences, and the quantitative and qualitative methods used to carry out this study, which is aimed at answering our research questions:

Do students believe that they control their learning process during PBL? Does PBL increase the interest of the students? Do students perceive the usefulness of what they have learnt? What are the issues of large workgroups? What is the perceived workload of students? How do the students perceive the labour of their facilitator?

3.1 Organization and participants

The experience involved 199 students (15.3% women and 84.7% men). All students were enrolled in a common subject that is both technically and vocationally oriented. The selected subject (Ship's Auxiliary Systems) is taught at the Polytechnic School of Engineering at the University of La Laguna, and it is compulsory for students entering the degrees of Marine Technologies and Maritime Transportation.

Most of these students entered university for the

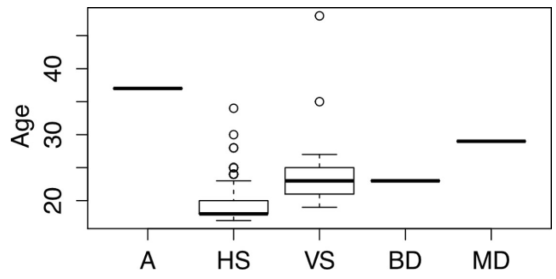

Fig. 1. Distribution of ages depending of the students' previous education. A: Specific access for students over 25 years old; HS: High School; VS: Vocational School; BD: Bachelor Degree; MD: Master Degree.

first time from high school (HS; n = 164; 82.4%), but there was a significant rate of more experienced students who came from vocational schools (VS; n = 27; 13.6%). A smaller proportion of the students (n = 8; 4.0%) held either a previous bachelor's degree (BD; n = 5; 2.5%) or master's degree (MD; n = 2; 1.0%), or accessed the university by a specific exam for students older than 25 years old (A; n = 1; 0.5%). Overall, most of the students were quite young: at the time of enrolling 75% of the students were aged between 17 and 21 years old; however, age groups are distributed differently depending on whether students already held higher education qualifications, as seen in Fig. 1. The median age of the students coming from high school (18 years old) is significantly lower than the median of students from vocational schools (23 years old).

It was not possible to reorganise the actual structure of the curriculum at this university. Consequently, the approach was to readapt the selected subject to accommodate PBL. Before introducing PBL, the subject's weekly time was scheduled to include 1 hour for conventional courses, 1 hour for problems, 1 hour for practical lessons in reduced groups, and 4.5 hours for autonomous learning. During PBL it was restructured as follows: 1 hour for conventional courses, 1 hour for short traditional problems, 1 hour for meetings with the facilitator, and 4.5 hours for PBL work. The main goal of these changes was to allocate time for teamwork and project work. As a result, the subject was split into two parts: active learning through PBL, and conventional courses and short problems to support PBL; both tutored separately.

For the PBL, four lecturers participated as facilitators, two of them also had teaching responsibilities in the selected subject. Due to the large number of students, 12 large groups were necessary to be able to schedule weekly meetings. Groups were assigned to the facilitators based on their previous experience on PBL and their time availability (see Table 1). Students were allowed to join to any group freely, resulting an average size of 17 students per group. When each group was formed, the students were told to choose a team leader and to create their own rules.

Table 1. Students assigned to each facilitator

Facilitator	Groups	Students
F1	4	71
F2	2	31
F3	5	86
F4	1	11

3.2 The problem-solving process

The problem was common to all groups, and it was designed to occupy a whole semester. During this period, each group of students had to develop a project to solve the problem. During the initial weeks, students were instructed about the basis of PBL, the problem-solving process, and the assessment procedures of the subject.

At the beginning of the course the students were given the following question: *Can you think any way to design a small-scale model that simulates the operation of a tanker?* Each team of students had to answer this question by developing a project. As learning goals, they had to include the basics of piping, fittings, pumps, fluid mechanics, and head loses. Students had to face this challenge involving teamwork, having to deal with people with different ideas and different levels of motivation.

Facilitators were responsible for guiding the students to learn how to find the right information, managing the group, and helping them to solve their conflicts. Facilitators also had to encourage the students by helping them to recognize their errors, and motivating them to achieve their goals. Finally, they had to guide the students in the writing of the final report, to ensure that it was at an appropriate college academic level. Consequently, the role of the facilitator was more "tutoring for the process" than "tutoring for the subject". During the guidance, the facilitators imposed certain limitations to students to avoid dispersion in the problem-solving process. Thus, the students' designs had to be simple, small, with easy to find components, cheap, and didactic. In the end, the students designed and calculated different systems, and finally wrote their reports, which were also the basis for the group exam. In the exam, which was conducted by experts, each student was individually assessed by demonstrating his or her understanding of the design used to solve the problem and the underlying technical principles that made it work.

3.3 Instruments

The instruments used were based on the MUSIC Model of Motivation [38, 39], and the MUSIC

Model of Academic Motivation Inventory (MUSIC Inventory) [46]. The questions were adapted and translated into Spanish to fit with the PBL experiences. The college version of the MUSIC Inventory consists of 26 items that comprise five scales to measure students' beliefs about the five components of the MUSIC model: empowerment, usefulness, success, interest, and caring. The MUSIC Inventory has been shown to be reliable and valid for use with college students [40]. Reliability estimates for the Spanish version of the MUSIC Inventory used in the present study are provided in the Results section. In addition to the MUSIC Inventory, open-ended items have also been used to assess the students' and facilitators' beliefs about the MUSIC components (see [46] for examples). The questionnaires were answered anonymously by the students immediately after they completed the group exam. The facilitators answered their questionnaire after the group exam was graded.

3.4 Quantitative analysis

Although the reliability and validity of the MUSIC model and inventory has been confirmed [43], the reliability and the internal consistency were tested for each MUSIC model component by using the Cronbach's Alpha reliability (α_{raw}) [47] and the corrected item-total correlation (r_{drop}) [48–50]. Test reliability was considered acceptable if $\alpha_{raw} > 0.7$ [47], and internal consistency was ensured if $r_{drop} > 0.3$ [48–50].

Data obtained from the MUSIC inventory was not normally distributed and did not succeed the Anderson Darling Test [51]. Consequently, the comparison between sub-groups was calculated by using non-parametric tests. Thus, the Wilcoxon rank-sum test or the Kruskal-Wallis test was used depending on the number of sub-groups for each comparison [52]. Non-parametric *post hoc* tests were performed by comparing differences between mean ranks against critical differences [53]. In addition, the Jonckheere-Terpstra test was used to confirm the existence of tendencies in the measured level of motivation. The quantitative data from the MUSIC Inventory was analysed using R 3.1.3 [54], including the packages *pshych* 1.5.1 [55] and *pgirmess* 1.5.9 [56].

3.5 Qualitative analysis

The qualitative information obtained from open-ended questions was analysed using an open coding approach [57]. Each open-ended question was transferred to a text file with the comments of all interviewed students. After a first reading, two researchers extracted an initial two-level coding hierarchy for each question. Afterward, we coded each file containing the responses to each open-ended question by successive scanning by different researchers to increase the detail. The coding process was comprised of tagging pieces of text linked to the coding hierarchy. Consequently, the initial hierarchy was fine-tuned dynamically and altered when necessary, and was independent for each question. To visualize students' answers, tagging was quantified and mapped for each open-ended question. By contrast, the answers of the facilitators did not require quantifying to visualize their ideas; instead, the codes were grouped to synthesize their opinions. TAMSAnalyzer 4.47 [58] was used as part of the qualitative research process.

4. Results

4.1 Quantitative results

A total of 128 students answered the questions of the MUSIC Inventory. When answering the questionnaire, the students' answers were grouped by giving additional information about their gender (G), age (A), scholarship support (S), academic background (B), their parents' academic background (P), their actual employment status (E), and their facilitator (F) (Table 2).

The reliability tests showed that the scores for each of the MUSIC Inventory scales were good or very good. In all cases $\alpha_{raw} > 0.86$ (see Table 3) and $r_{drop} > 0.57$, and the reliability if an item is removed (α_r) did not increase significantly.

In the comparison of the five components of the MUSIC Inventory in all subgroups, only F (Facilitators) and G (Gender) showed statistically significant differences across the five components. Specifically, differences were found for facilitators for *Empowerment* and *Caring* (Table 4). The *post-hoc* tests showed statistically significant differences between facilitators F2-F3 for *Empowerment*, and facilitators F2-F1 and F2-F3 for *Care* (Table 5, Fig. 3). For gender, differences were found for *Empowerment*, *Success*, and *Interest* (Table 6). Females reported less empowerment, had lower perceptions of success, and were less interested than the male students (Fig. 2).

Furthermore, the analysis of tendencies through sub-groups shows a decreasing feeling of interest from the students accessing the university from high school, compared to those accessing from vocational schools (Table 7). The interest also varies depending on the educational background of their parents: the higher the educational background, the lower the interest (Table 7).

4.2 Qualtative results from students' answers

A total of 153 students answered the open-ended questionnaire. The findings in this section represent the results of the qualitative analysis related to the

Table 2. Description of the students

Groups	Sub-groups				
Gender (G)	**Male**	**Female**			
	109	19			
Has a scholarship (S)	**No**	**Yes**			
	83	45			
Employment status (E)	**No**	**Yes**			
	99	29			
Age (A)	**18**	**19**	**20–22**	**23–49**	
	42	26	23	37	
Facilitator (F)	**F1**	**F2**	**F3**	**F4**	
	42	22	57	7	
Parents' Academic Background (P)*	**BS**	**M**	**H**	**WF**	
	42	34	41	11	
Academic Background (B)**	**A**	**HS**	**VS**	**BD**	**MD**
	1	98	24	3	2

* BS: Basic; M: Intermediate; H: Higher education; WF: Without formal education.
** A: Specific access for students over 25 years old; HS: High School; VS: Vocational School; BD: Bachelor Degree; MD: Master Degree.

Table 3. Reliability tests

Component	α_{raw}
Empowerment	0.87
Utility	0.92
Success	0.86
Interest	0.89
Caring	0.90

students' answers. The numbers presented in parentheses throughout the results show the iterations of each code, but they are not strictly related to the total number of answers because the students did not always give further explanations to their main answer. Therefore, the quantification of the first level code is not always equal to the sum of the

Table 4. Results of the Kruskal-Wallis test (p-value)

Sub-Groups	Empowerment	Usefulness	Success	Interest	Caring
Ages	0.64 (1.67)	0.38 (3.07)	0.99 (0.10)	0.58 (1.94)	0.21 (4.50)
Background	0.77 (1.78)	0.93 (0.88)	0.57 (2.93)	0.35 (4.46)	0.29 (4.94)
Parents' background	0.87 (0.72)	0.37 (3.12)	0.67 (1.55)	0.15 (5.36)	0.28 (3.81)
Facilitator	**0.04 (8.44)**	0.72 (1.32)	0.38 (3.06)	0.33 (3.45)	**<0.01 (24.83)**

Note: In brackets the test statistic H.

Table 5. Results of the *post hoc* tests of sub-groups between facilitators

Component	Facilitators	Observed	Critical	H_1
Empowerment	F2-F1	21.93	23.37	False
	F2-F3	25.84	22.29	**True**
	F2-F4	29.60	38.54	False
Care	F2-F1	46.99	23.37	**True**
	F2-F3	38.98	22.29	**True**
	F2-F4	36.94	38.54	False

Note: The method compares the observed ranges with the critical ranges. If the value of the observed ranges is higher, then the alternative hypothesis H_1 is true with $p = 0.5$.

Table 6. Results of the rank-sum Wilcoxon test (p-value)

Sub-Groups	Empowerment	Usefulness	Success	Interest	Caring
G	**0.0008 (534)**	0.1184 (803)	**<0.0001 (411.5)**	**0.0096 (649)**	0.1194 (803.5)
S	0.1052 (1543.5)	0.7484 (1803)	0.5561 (1749.5)	0.2491 (1636.5)	0.992 (1870)
E	0.9499 (1447)	0.1159 (1711)	0.4804 (1311.5)	0.8664 (1405.5)	0.9590 (1445)

Note: In brackets the test statistic W. G: Gender. S: Scholarship support. E: Employment status.

Table 7. Tendency Jonckheere-Terpstra tests

Sub-Groups	Component	Tendency	p-value
B	Interest	Decreases from BC to FP	**0.041 (920)**
P	Interest	Decreases from BS to M to S	**0.047 (1946)**

Note: In brackets the test statistic JT. The tendency was tested under the alternative hypothesis in column Tendency using 1000 iterations. B: Students' academic background. P: Parents academic background. BC: Students accessing from High School. FP: Students accessing from vocational schools. BS: Basic educational background. M: Medium educational background. S: Higher educational background.

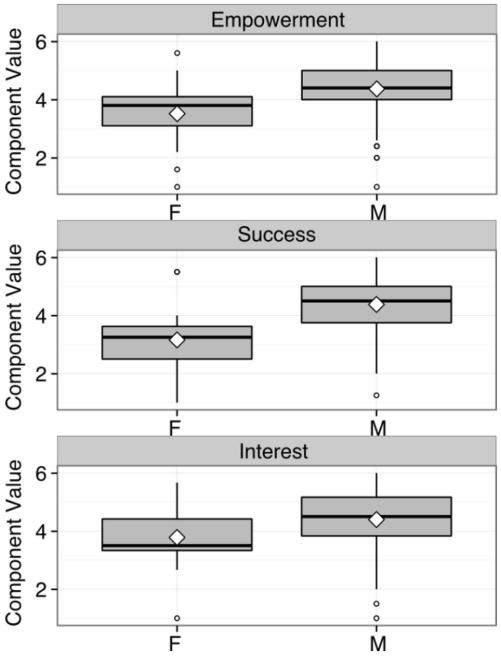

Fig. 2. Boxplots of the MUSIC components that show differences between genders. Item values for each component measured with a Likert Scale from 1 (strong disagree) to 6 (strong agree).

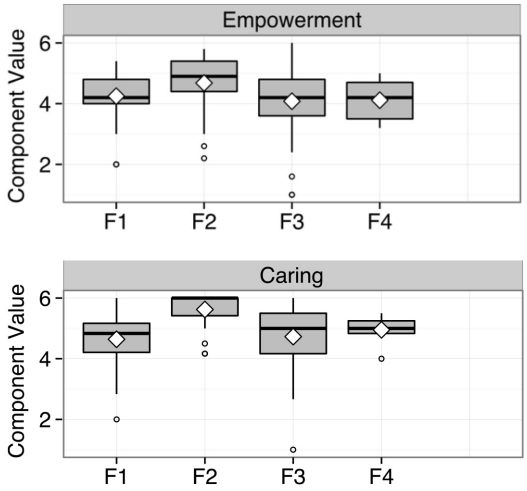

Fig. 3. Boxplots of the MUSIC components that show differences between facilitators. Item values for each component measured with a Likert Scale from 1 (strong disagree) to 6 (strong agree).

related second level codes. For clarity, the first level of the hierarchy is marked in bold. After the results of the qualitative analysis of each question, there are brief selections from the students' answers for better illustration.

- ***Sense of control: Which aspects of the project have you been able to control?***

Part of the answers **(26)** quantified their feeling of control: 2 affirmed not to have any control, 5 controlled "just a few aspects", 3 controlled "some aspects", 5 controlled "nearly everything" and 14 affirmed to have controlled "everything". A larger number of answers **(53)** were related to the control of different parts of their project: components (31), calculations (13) and drawings (8). Another section of student answers **(26)** was related to their freedom to manage their team (15) and organise their own tasks (11).

> "All aspects. Everything was though from scratch, without any obstacles".
>
> "Some parts of the project, but we were not able to decide which project had to be developed".
>
> "We could not make many decisions, because we were oriented (by the facilitator) to a specific direction".

A significant proportion of the answers **(50)** simply did not understand the question: they confused the term "control" with the idea of being able to understand or dominate the project.

> ". . . pumps, valves, filters, piping, tanks, accessories, etc . . .".
>
> "How to calculate head losses and valves".

- ***Freedom to make decisions: Which decisions were your team able to make regarding its functioning?***

The answers to this question reveal that students felt free to make decisions linked to their own organisation **(36)**, and the assignment of individual tasks **(24)**. About one fifth of the answers **(32)** referred to the possibility of making decisions related to technical aspects of their project; an analogous amount of answers **(35)** simply quantified their sense of freedom as "none" (2), "few" (5) and "many" (28).

> "We've had freedom. We wrote our team rules at the beginning, which did not contemplated pun-

ishments, but this implied that all of us worked and gave our opinion''.

''We could decide how the team functioned. We decided it at the beginning''.

''Just how to organize ourselves, because at the beginning the facilitators didn't know what they wanted us to do''.

- ***Results of the team decisions: What have the results of the decisions made by your team been?***

The biggest proportion of the answers **(105)** quantified the answer. Most of them referred to ''satisfaction'' with their decisions (67), or felt them as ''acceptable'' (10). A smaller amount answered ''some decisions were good and others not'' (20). Only 8 answers quantified all their decisions as ''wrong''. Other answers **(15)** revealed that taking their own decisions derived into self-improvement, the delivering of a good project, and an improvement in their learning process.

''We had good results at the end even some team members didn't want to collaborate at the beginning''.

''We took the wrong decisions at the beginning, because we had many doubts about how to continue with the project. However, when we gained experience we were able to make important and correct decisions''.

- ***Decisions made by the facilitator: What decisions did the facilitator make?***

Regarding this question, a significant number of the answers **(51)** revealed that the facilitator made decisions related to the technical aspects of the project. A similar amount **(64)** answered that the decisions made by the facilitator were more related to guiding tasks (53) and organisational aspects (11). The rest of the answers **(17)** quantified the amount of the decisions made by the facilitator: 11 said that the facilitator ''did not make any decision'', and 6 quantified them as ''few''.

''Instead of making decisions, he always tried to orient or to organize us . . .''.

''The facilitator always answered our doubts with questions, he never gave us anything solved . . .''.

''. . . specially in the halfway of the semester because we were in the wrong path''.

- ***Need of more control: Would you prefer the facilitator had more control?***

About one-half of the answers **(73)** correspond to students that do not want more control from their facilitator. Just some of them (3) clarified that not having such control ''permits gaining more autonomy''. Roughly the other half **(66)** would prefer to be more controlled, but a representative part of these answers (15) specify that ''only at the beginning'', and a similar part (12) revealed that they ''needed more information''. One of the answers manifested ''disorientation''.

''Yes, for not being so lost. But this has taught me working on my own''.

''No, because this would not drive us to discover things by ourselves''.

''Yes and no. I would have preferred more control in aspects like the control of students' attendance. In other aspects not''.

- ***Knowledge and skills usability: How will what you have learnt be useful during your studies and your professional life?***

The biggest proportion of the students' answers **(58)** finds their knowledge and skills to be relevant for their professional life. In decreasing interest, they found the following aspects relevant: teamwork **(25)**, easier knowledge acquisition **(22)**, easier understanding of technical aspects **(21)**, easing of their learning process **(20)**, and making it easier to face future problems **(17)**. Other less mentioned aspects were related to their own personal growth **(7)**, individual work **(6)**, communication **(3)**, and resources management **(2)**.

''. . . in the ability of team-working efficiently and learning how to elaborate solutions''.

''. . . this way of learning shows me how will my professional life be in some years, and how I should behave for these situations''.

''. . . I am convinced that this project will be useful today''.

''It will have an important role in defining the person I can be, not just professionally, but also in my personal life''.

- ***Feeling of being competent, overwhelmed or bored: Which aspects made you feel competent, overwhelmed or bored?***

The analysis of this question reveals that students felt competent **(94)** especially when they were able to understand concepts by themselves (32), reached their goals (31), and were able to make valid contributions (16). On the other hand, they felt overwhelmed **(76)** mainly by difficulties in understanding concepts (18), the complexity of the project (15), and the absence of previous knowledge (14). They also felt overwhelmed by initial disorientation (8), not being able to reach their objectives (7), the face-to-face presentation (4), and an overload of work (4). A minor proportion of the students

felt bored **(15)**. This affirmation was caused principally because of repetitive work (7), the lack of productivity in their team (4), or the inefficient sharing of tasks (2).

> ''. . . feeling that I was able to understand things that I didn't comprehend during other courses, and the fact of being able to apply them''.
>
> ''. . . the feeling of 'I don't know how to do it'. . .''.
>
> ''. . . bored because of the evident deterioration of our team''.

- ***Received help from the facilitator: What help did you receive from your facilitator?***

Most of the answers describe the perception of receiving support in the form of orientation to solve the problem **(65)**, and knowledge **(49)**. Other aspects perceived by the students were group dynamics **(7)**, and the ''human aspect'' **(2)**. A smaller group **(26)** quantified their perception of the help received from their facilitator as: ''none'' (5), ''poor'' (2), ''just the necessary'' (2), ''much'' (4) and ''a lot'' (13).

> ''Mostly orientation; he said when we did right, and he refocused our problem when we did wrong''.
>
> ''. . . encouraged us and tried to calm us . . .''.
>
> ''. . . helped with knowledge''.
>
> ''. . . helped us boosting our team dynamics''.

- ***Received help from the group: What help did you receive from your team?***

The students affirm that they received help from their team in the form of knowledge **(54)**, teamwork **(33)** and also companionship **(18)**. One of the students stated ''feeling protected'' by his team. Part of the answers **(47)** quantified their perception of the help received as ''much'' (27), ''enough'' (3), ''poor'' (8), ''none'' (8), and one of them manifested explicitly repulsion against teamwork.

> ''Each team member studied one part and then explained to the rest of the partners''.
>
> ''Having team members with previous knowledge supposed a positive impact''.
>
> ''Confronting problems together''.
>
> ''. . . when one of us collapsed, others helped''.

- ***Team learning: Do you think you have learnt more due to working as a team?***

Students felt that teamwork has a positive impact in their learning. The biggest proportion of their answers **(109)** is aligned with this idea. They think that most of it is caused by the effects of collaborative learning (67), but also because they have been able to organise their own work (21), and also by being able to discuss ideas or concepts (10). Some of the students (7) think that teamwork has a positive effect on individual work. Students that felt a negative impact **(16)** said that it was caused by the size of the groups (4), too much specialisation of their team members (4), and the irresponsibility (2) and individuality (2) of some students.

> ''. . . while working on different aspects, we established discussions which are useful to internalize learning''.
>
> ''Yes, because I learnt more than working alone''.
>
> ''. . . the requirement of coordination and teamwork is an experience that does not exist by answering an individual exam''.

- ***Initial interest: Describe your initial interest.***

A significant proportion of the students' answers **(74)** affirmed them to be previously interested in the subject. A smaller proportion **(38)** were not interested previously. Some of the students **(3)** stated a passing interest in the subject. Part of their answers **(89)** quantified their initial interest as ''none'' (15), ''poor'' (17), ''medium'' (10), ''much'' (31), ''very much'' (13), and ''the same as other subjects'' (3).

> ''. . . teamwork gained my attention a lot''.
>
> ''I really felt passionate the way they were going to use to make us learn, and know I think it is one of the better ways to learn''.
>
> ''. . . not too much, just passing the subject''.

- ***Final interest: Describe your final interest.***

Nearly half of the students' answers **(73)** manifested an increased interest. They recognised a positive effect caused mostly by feeling competent (21), relevance to the real world (16), the novelty of this way of learning (8), or because they had reached their objectives (5). A more reduced number of answers **(26)** stated feeling the same level of interest than at the beginning, mostly because it was still high (11) and they still wanted to learn (2); others because they felt disappointed (2), just wanted to pass the subject (2), or simply were not interested at all (1). The rest of the answers **(16)** recognised a reduction in interest, most of it because of conflicts within their own team (5), excessive workload (4), a sense of disorganisation (3), not feeling competent (2), or just because of a preference for the traditional learning method (2).

> ''I love it. Now I am sure I chose the right path for my professional life, thanks to this subject and its learning method. I've lived the experience of an engineer . . .''.

"My interest is increased when I've seen the productivity of what I've done".

"It is something that we needed. Not just books and notes, but also discussions and the comparison of ideas, something that will be great when getting into the labour market".

"It is the same that at the beginning".

"I still feel the same interest of learning and joining in a project".

"Now I don't feel very motivated nor engaged in this subject. Perhaps due to the lack of organizing associated to this new way of teaching".

". . . not too much, just passing the subject".

- ***Teamwork effects over interest: Do you think that teamwork boosted your interest? Why?***

The analysis of the answers to this question shows that many students **(101)** perceived an increase in interest caused by: receiving help from others (21), being able to assume their own responsibilities (8), collaborating and contributing to their team (7), feeling entertained while learning (5), being able to discuss ideas (4) and reaching objectives (4), learning by themselves (4), and even making new friends (4). Other factors that may contribute to an increase in their interest are the sharing of difficulties (3), the ability to do new things (3), feeling the enthusiasm of other team members (2), or feeling important within their team (2). However, a significant number of answers **(37)** show a reduction in interest, especially motivated by conflicts (6), irresponsible team members (5), too many team members (4), indifference and individualism (3), too much workload (1), inexistence of companionship (1), or feeling ignored by other team members (1).

"Yes, seeing how all of us worked and collaborated made me to discover that all of us walked on the same direction".

"Yes, because the enthusiasm of others is contagious".

". . . I've always preferred to work independently, not having to depend on others . . .".

- ***Learning value over future learning: How will what you have learnt affect to your interest in other topics related to your project? Why?***

Nearly all respondents **(147)** think that what they have learnt has increased their interest in future topics, caused principally by the acquired knowledge (36). Part of their answers relates to an increase in their curiosity (32), some recognise a "practical orientation" (11) and others manifest an increased interest caused by the acquired skill (10). Other causes are related to their feeling of competence (5), professional interests (5), transversal knowledge (4) and improved critical thinking (2). Only a small number of the answers **(6)** do not describe an increase in interest, but of these, most of them (5) manifest a lack of previous interest or even amotivation.

". . . the knowledge I have right now awakens my interest in deepen in more aspects".

". . . now I'm understanding these topics and, if I've overcome this, ¿why no others?".

". . . it makes feel more confident".

- ***Interest in the problem: Did you feel interested? What made the problem interesting or made you feel indifferent?***

Practically all the answers **(141)** describe a feeling of interest in the problem for different causes: it was close the real world (31), eased their learning (12), it was a challenge (12), it was something new (11), it was orientated towards teamwork (11), it represented something different and new (11), the solving process was attractive (10), it was something complex (9), and it was a goal to reach (6). Other causes stated by the students included transversal learning (4), certain level of stress (3), the research process (3), the assessment method (2) or the contact with experts (1). Only some answers revealed a lack of interest in the problem **(10)** motivated by the difficulty of the problem-solving process (5), boring (2), inexperience (1) or simply because the individual wished to abandon their studies (1).

". . . I think that solving something complex is what it makes it interesting".

"It is something different from what we've been told to do until now".

"Yes, even when not having much knowledge, the proposal of something different makes you feel curious, what it is the base for learning something, without this curiosity the interest wouldn't exist".

- ***Teamwork organisation: Please describe your group's dynamics. How did you interact with your partners?***

The answers of the students were categorised in organisational aspects, social aspects and negative aspects. Regarding organisational aspects, students described the use of mobile devices and the Internet **(44)** and face-to-face meetings **(41)** as key organisational factors. Other relevant organisational aspects were the sharing of opinions and ideas **(19)**, "good organisation" **(15)**, companionship **(8)**, a hierarchical organisation **(6)**, the subdivision of groups and specialization **(2)**, discussions **(2)** and polls **(1)**.

Regarding social aspects, students recognise the

importance of respect **(6)**, mutual help **(5)**, compromise **(3)**, a calm attitude **(2)** and leadership **(1)**. As negative aspects, students highlighted "ups and downs" in their organisation **(6)**, the neglect **(6)** and indifference **(3)** of some team members, the shyness of some students **(2)**, some disorganisation **(2)**, the lack of recognition by some team members **(2)**, obligations between team members **(1)**, irregularities **(1)**, discrepancies **(1)** or even the rejection to teamwork **(1)**.

"With meeting and instant messaging . . .".

"Our dynamics consisted in small sub-teams, who were working on one specific aspect".

"Always with respect, and even sometime we talked at the same time, all opinions were listened".

". . . the team was so big that there was people that didn't do anything".

- ***Suggested changes in your team's organisation: What would you change about your group's performance?***

A big proportion of the students would not change anything **(39)**. In decreasing relevancy, other students would change aspects to improve their organisation **(23)**, and would impose sanctions on non-compliant students **(16)**. Other proposed changes are relative to improving implication **(9)**, the scheduling of the meetings to reduce conflicts with other subjects **(9)**, reducing team-size **(8)**, improving leadership **(6)**, limiting individualism **(2)**, improving the responsibility of some team members **(13)**, increasing dialog **(4)**, and imposing more control mechanisms **(4)**.

"Nothing, because we worked as expected . . .".

"A more equilibrated sharing of tasks. Also a way to kick out those who doesn't work".

"Class time for our meetings, it is difficult to organize a team of 14 members with different schedules".

"Less people and kick out those who don't do anything".

- ***Use of the Internet: How did social networks, mobile devices and the Internet influence your group's dynamics?***

In their opinion, ITs and mobile devices offer many advantages **(160):** they boost communication (53), improve organisation (21), permit the sharing of information and ideas (21), avoid unnecessary travel (17), ease the search of information (9), improve productivity (8), and help support the integration of team members (3). On the other hand, the students perceived some drawbacks **(9)**: merely using these technologies does not increase levels of interest (3), "worked worse than expected" (3), can cause conflicts if not used properly (2). In the opinion of one of the students, ITs are less effective than face-to-face communication.

"Having a mobile device by hand for asking anything and being answered immediately has always a positive influence".

". . . platforms like Google have been crucial for the development of the job, because we hanged there all the information and our planning".

"It eases the communication and brainstorming in moments that it was too difficult to stay all together . . .".

- ***Perceived caring from the facilitator: Did your facilitator show concern for your group?***

The majority of the students' opinions **(110)** showed that their facilitator was concerned for them. Most of their answers linked this feeling with actions like guiding (17), reorienting (13), pushing (13), correcting (11), observing (11), or clarifying (10). Other comments mentioned ideas like supporting (5), questioning (5), informing (3), advising (3), limiting (3), motivating (3), warning (2), giving options (1), interesting (1), intervening (1), criticizing (1), giving ideas (1), or even striving (1). However, some of their answers **(16)** stated they were disappointed because they felt that their facilitator did not help them with their problem much (5), he or she was not interested in their troubles (2), showed a lack of knowledge (1), did not strive (2), required the team to resolve their own problems with "non-compliant team members" (1), had too much work-load (1), was not concerned (1), assumed a high knowledge level at the beginning (1), ignored their difficulties (1), was only concerned about formal aspects (1), and seemed chaotic (1).

A total of **119** of their answers also quantified their answer: 110 manifested that their facilitator was concerned about them, (6) "just a bit", and only 3 affirmed that their facilitator showed no concern.

". . . the facilitator cared a lot, and was always looking out for us".

"Yes, he looked out for us to do the things right, but he also gave us freedom to solve the problems by ourselves".

"She was able to wake up our team when our project was sinking".

"Yes, when we had doubts he solved them, and when we had problems he gave us clues to solve them by ourselves".

- ***Suggested changes in the facilitator's role: What would you change in the role of your facilitator?***

An important proportion of the answers **(58)** explicitly affirm that they would not change anything. Other students would like more help **(11)** especially at the beginning **(7)**, more control **(9)**, more concise answers **(9)**, more information **(6)**, more feedback **(4)**, more meetings **(4)** and more concern **(2)**. Other ideas appeared only once in their answers: "less questions", "specialised courses", "being more enjoyable", "courses about teamwork", "less criticism", or "more contributions".

> ". . . we had too much freedom at the beginning, and if the facilitator had focussed us we had done it better".
>
> ". . . principally the control of the work of each component".
>
> "The facilitator should establish clear goals for better developing our project".

- ***Workload: Do you think that workload has been too high?***

Most of the answers **(91)** were linked with the idea of it being very time-consuming, but 14 of them thought that it was worth it. Interference with other subjects was also an issue **(14)**. A few stated that poor organisation caused a high workload **(3)** and complained about their lack of previous knowledge **(3)**; others associated high workloads with the idea of complexity **(6)**, the challenges presented by the learning method **(2)**, conflicts within the group **(1)**, or because the group being oversized **(1)**.

> "It's consumed much time, but I would do it again because of the knowledge I have obtained".
>
> "It's been more time demanding than other subjects or studying for an exam. But it's been entertaining and comforting".
>
> "No, because it didn't require more hours than necessary with good organizing".

4.3 Qualitative results from facilitators' answers

The following shows the synthesis corresponding to the answers of the facilitators to the open questionnaire. The quotes represent or exemplify the results by using part of their original answers.

- ***Sense of control: Do you think that the students have been able to control any aspects of their learning?***

From the perspective of the facilitators the students didn't develop the skills required to control their learning at the beginning: ". . . they didn't want it nor desired this control", ". . . students had freedom at the beginning, but they didn't know how to confront the problem". This required orienting them at the beginning ". . . to make them discovering their goals". The facilitators tried increase the students' control by asking them to write up their own team-rules. However, the students didn't apply these rules to their conflicts, in the facilitators' opinion, ". . . because a lack of proper training and authority".

In the opinion of the academic staff, the facilitator was the unique vehicle the students have to control their learning process: ". . . it wouldn't be possible without the facilitator". The facilitators think that the difficulties of the students in controlling their learning was linked to the inexistence of training and the previous skills of the students: ". . . there was lack of previous training, including the facilitators", ". . . the problem was too wide and difficult for the skills of first year students". Even the facilitators think that the students got some control at the end, it was not sufficient: ". . . they got some control, but it was too late and they didn't have time enough".

- ***Empowerment: Do you think that you have empowered the students to make them learning by themselves without any manipulation?***

At the end of the experience the facilitators perceived that the students were somewhat empowered: ". . . they've demonstrated themselves that they were able to do it", ". . . they felt useful and capable". But the initial motivation of the students seems not to be homogeneous in the opinion of the facilitators: "I didn't find students intrinsically motivated", "I found two types of students: those who love learning by themselves, and others that are just not interested in learning". It seems that the highly motivated students were more individual and this motivation was not spread to the rest: ". . . I didn't observe any special motivation for learning by themselves", ". . . the empowerment was more individual than team-based".

However, the facilitators agree that they were forced to influence the students with some degree of manipulation: ". . . they are used to manipulation", ". . . because they border the apathy". Aligned to this, the students did not react until they felt stressed: ". . . they didn't react until they started feeling some pressure at the end of the process", ". . . when the deadline was really close". The manipulation was used by the facilitators to make the students to reach their goals: ". . . I had to be severe in some occasions". For this purpose, they used positive or negative statements (external motivation): "I would like to be proud of you", ". . . I feel disappointed".

- ***Utility: Do you think that the students perceived what they learnt is useful for their personal interests, professional goals, and real life?***

The facilitators perceived that the students discovered the utility mostly when they finalized the

experience: ''. . . they felt that it is useful principally at the end''. In all, the facilitators clarify that the students still have a partial vision regarding the usefulness of their learning: ''. . . their vision is skewed, which is caused by their partial vision'', ''. . . it is still difficult for them to have a useful vision, but they have perceived the utility at the academic level''. Nevertheless, the facilitators think that the perception of utility may be boosted by more practical approaches: ''I think that including the building of their ideas would improve this aspect''.

- ***Effect of PBL over learning: Do you think that the students perceive that they have learnt more through PBL?***

There is a positive effect of PBL over the students perceived by the facilitators: ''. . . the students realized that it is a learning method that reinforces their motivation'', ''. . . they worked individually while understanding the relevance of teamwork''. In spite of this, there are aspects that imply some weaknesses: ''. . . the students have a natural tendency to specialize and not having a global vision of the problem'', ''. . . they corrected their communication problems only at the last stages of their project'', ''. . . they only used the team-work tools when they really found them necessary''. In fact, communication skills of each team seems linked to their success in reaching their goals: ''. . . the teams that were able to share more were more successful''.

- ***Learning challenges: Do you that the learning process has supposed a challenge to the students, or by contrast they have perceived as not too hard or even easy?***

The facilitators stated that the students perceived the problem as difficult: ''. . . it was hard and difficult at the beginning'', ''. . . they perceived it was difficult, and they were doomed to failure'', ''. . . it was difficult for them organizing the information at the beginning and defining their learning goals'', ''. . . the students don't know what to do probably because of the inertia of previous traditional learning environments''. Team-work supposed also a challenge for the students: ''. . . working in teams, and also the use of teamwork tools'', ''. . . communication and oral presentations''. However, the facilitators opinion is that the difficulties were reduced as the students worked on their projects: ''. . . they realized that it was complex because they complicated it''.

Unlike the difficulties that the students faced at the beginning, the facilitators identified several aspects linked with the feeling of competence of the students: ''. . . they found it enjoyable as they overcame obstacles'', ''. . . it was satisfying in occasions, specially at the end, when they felt competent . . .'', ''. . . after they delivered it, the problem was not a challenge nor difficult for them, because most of the students felt competent'', ''. . . the students really enjoyed when they were able to explain anything to other students''.

- ***Feedback: Did you give any feedback to the students about their learning process?***

The facilitators established aspects that link and adequate feedback with PBL: ''. . . it avoids conceptual difficulties'', ''. . . one of the most successes of this system is the possibility of real time feedback'', ''. . . the students need any reference from someone''. The facilitators adopted strategies to maintain the students informed about their progress: ''. . . saying what they had finished and what was still pending''. Two of the facilitators tended to focus the feedback on what the students were doing wrong: ''. . . it was usually to tell them that they never complied with their deadlines'', ''. . . it was more focused on what they did wrong in order to improve it, than on what they did right''. Only one of the facilitators stated the relevance of positive feedback: ''They should know what they do right and wrong. The students also need recognition to improve their self-esteem''. Moreover, there exist other factors that have a negative influence on the feedback that the facilitators gave to the students: ''. . . the high workload made me not to personalize the feedback for each student''.

- ***Success: Do you think that the students feel that they will success in future problems if they put the required effort on them?***

The facilitators found a positive effect in the ability of the students to face future problems: ''I think that the feeling of competence had a big impact on them'', ''. . . they've perceived the link between effort and success''. But this feeling in the students is not homogeneous in opinion of the facilitators: ''In general yes . . .'', ''Not all of them'', ''. . . others just think that they had 'survived' and expect not to face a similar situation'', ''I don't think that they've finished knowing that they will success if they put effort into, they lack of more critical thinking''. The facilitators perceived asymmetries in the effort of the students: ''. . . there are students that succeeded with less effort thanks to the work of the team''. In opinion of one of the facilitators, this asymmetry may limit the motivation: ''I think that this undermines the feeling of success of those who put more effort''. Added to that, the facilitators think that the perception of the students is still limited by their experience: ''. . . it is an isolated experience, which is poor for these goals''.

- ***Interest: Do you think that the students took interest in the knowledge and skills required?***

In general, the facilitators perceived an increment in the students' interest, but they clarify their answers: ''. . . it depended upon the degree the students were enrolled at'', ''. . . they were more interested in skills than knowledge'', ''. . . there was a gradual increment in skills and knowledge'', ''. . . their interest grew as a consequence of their feeling of usefulness of team-work skills and what they were learning''. In opinion of one of the facilitators, the interest grew mostly at the end: ''the largest proportion of the increment of their interest occurred when the project was on an advanced stage''.

- ***Perception of caring: Do you think that the students perceived that you did care for them and their well-being, independently their success?***

Regarding this question, the facilitators stated that the students did not have a clear idea of their role: ''. . . they calmed down when they discovered that the role of the facilitator was not to assess''. However, in the case of the facilitators who were assigned as lecturers for the subject, there was still some fear: ''. . . many students didn't want to approach to ask, probably because they feared my answer''. One of the facilitators valued the students' perception of caring just in academic terms: ''. . . they've valued the many marks of the assessing procedure''.

In the facilitators' answers, their appreciations of the students' perception seem linked to the way each facilitator manages the barriers in communicating with the students: ''I've observed some indifference and I couldn't intervene in their conflicts'', ''. . . a more familiar environment was missing, so they had not perceived me as a lecturer to assess them''. When a relaxed environment was possible, the appreciations of the students' perception improved: ''I could discuss some personal details, thanks to the relaxed conversations after formal meetings'', ''. . .most of my guidance was oriented towards personal difficulties''.

5. Discussion & critical reflection

This study assessed students' perceptions of the five components of the MUSIC Model [27] at the end of a PBL experience in an engineering course, and compared its results by gender (G), age group (A), scholarship support (S), academic background (B), parents' academic background (P), employment status (E), and assigned facilitator (F) (Table 2). The study also analysed qualitatively the students' and facilitators' responses to the open-ended questions that we asked to obtain their beliefs about the PBL process.

The quantitative analysis did not show relevant differences, except for a few with respect to gender (Table 6 and Fig. 2) and the assigned facilitator (Table 5 and Fig. 3). Female students that participated in the PBL felt less empowered, less successful, and less interested than males. However, the number of female students that answered the questionnaire (n = 19, 14.8%) may be too small to allow us to extrapolate this result to all female students and requires further attention by the teaching staff.

The results comparing different facilitators indicate that the teaching staff have an influence on the students' motivation, especially in relations to students' perceptions of empowerment and caring, independent of the difficulty of the problem. This is important because it shows that even when instructors implement the same curriculum, their teaching behaviours can be interpreted differently by students. Future research could examine differences between instructors to determine which types of teaching behaviours lead to increased perceptions of the MUSIC model components. What is more, the differences on each scale of the MUSIC Inventory may be a good quality indicator of the labour of the teaching staff (Fig. 3). Also, the analysis of the quantitative answers reveals that the interest perceived by the students varies depending upon their own academic background and the academic background of their parents (Table 7). This makes it important to identify the students' expectations that may affect their interest at the end of the PBL process.

The qualitative analysis revealed that initially the students felt confused and frustrated about the role of their facilitator. This was the result of their preconceived expectations of classes: they thought they would be passive recipients of knowledge. Instead, they were asked to take control of their own learning process. In general, the students did not perceive the guidance of the facilitators to be an excessive external control, which can help them to maintain their motivation [38]. Actually, they would have preferred to have more support at the beginning of the course. PBL had a positive impact on students' motivation: they felt empowered and competent/successful, and their interest increased. In general, they felt satisfied with their own decisions, even though in some cases they may have been wrong. Interest levels increased as a result of several factors related to the caring component of the MUSIC model, including the mutual help they received, the sum of emotions they felt when they were integrated in their team, the shared burden of responsibilities and problems, and their enthusiasm when they reached their goals. A weak background

had a negative effect on the students' sense of competence and success. They did not seem self-conscious of this factor when asked about their perceived interest because no one mentioned this explicitly, but the most relevant change when asked about the facilitator's role was that they wanted "more help". This can be linked to the perceived workload, given that the students believed that PBL was time-consuming. Moreover, the students felt stressed because the workload in this course interfered with other subjects, and they thought that the PBL was complex, which took more time to retrieve the required knowledge.

Team-work was perceived by the students as useful for their future and had positive effects: the students perceived that it eased the acquisition of knowledge, helped them to understand the technical aspects required for their projects, and improved individual work. Students valued positively what they learnt with regards to their curiosity, the utility, and the skills acquired. However, the reduced number of facilitators required large groups. This caused conflicts and decreased the interest of some students because of freeriders, irresponsibility, being ignored, indifference, or individualism. Additionally, students tended to reorganize in smaller sub-groups and to specialize. This is not a negative issue in large projects, but it is not ideal in smaller projects as there are not enough tasks for all the students, and they also tend to not recognize the whole picture. The lack of communication during their learning process also complicates this vision. Nevertheless, even if the perspective of the students is limited by these aspects and it is linked to just one active learning experience, there is a positive effect in the capacity of facing future problems, thanks to the feeling of competence that links together their success and the effort they put into the PBL process.

In the opinion of the facilitators, the students did not develop all the skills necessary to fully control their learning process. The students had empowerment and freedom initially, but they also had difficulties in facing the problem at the beginning of the process, which was probably caused by the lack of previous knowledge and skills. The facilitators did not perceive a homogeneous motivation of the students at the beginning of the PBL. Like in traditional subjects, they encountered very motivated students and others not interested in learning. Facilitators also observed some individualism, even though it did not affect all the groups equally. These issues probably caused students to react only under pressure when the deadline was close and the facilitators started to push students to work harder and tried to manipulate them. However, this manipulation was not a strategy derived from the consensus of the facilitators, but was the result of the reactions of each facilitator. These differences may have contributed to why some facilitators were rated higher than others by students on empowerment and caring on the MUSIC Inventory. Some of the facilitators' reactions were positive and they tried to motivate their students; others were more negative because they tended to be more severe or controlling. Facilitators also tried to motivate the students by giving feedback about their learning process. However, this feedback was mainly focussed on those aspects that had to be corrected and did not always value positively the work of the students, or was limited by the workload of the facilitators. Lastly, the facilitators perceived that the students were confused in their role at the beginning. This confusion was increased when the facilitators also had teaching responsibilities in the subject, which created the tendency of the students to be less communicative with their teachers. The existence of barriers in the communication had a negative impact on the students' motivation, as this restricted their perception of caring.

6. Conclusion

The introduction of PBL into a university course can empower students to control their learning process and increases their interest, both as a consequence of the problem-solving process and teamwork. Nevertheless, to become motivated, students need skills and a solid knowledge base before facing a complex problem. In other words, to keep their feeling of control of their learning process, the students need guidance, especially at the beginning.

Team-work was perceived by students as the most important skill acquired through the PBL process, but it created frustration when they did not have a good structure to organize their work to share responsibilities. If students do not have the required organizational and communication skills, these difficulties can be complicated by the effect of large group sizes, and may cause conflicts and the reduction of interest as the result of freeriders. When the problem is complex, students tend to focus their effort on concrete aspects, but this lack of organizational skills also lead them to not knowing how to transfer their findings to other teammembers. This reduces the students' overall perceptions of the PBL process. In addition, when the students do not share their responsibilities during PBL, they become overloaded, which can lead to frustration. Finally, communication difficulties can also affect the students' perceptions of their facilitators. Students need feedback to improve, but also to reinforce their self-esteem, their perception of competence, and feeling of success. The lack of information feedback may also have a negative

effect on the students' perceptions of caring, and can create additional difficulties in PBL.

As a conclusion, even when PBL is accepted by the students and it is gradually introduced in a university course, it is not exempt from difficulties. Some of these issues can be addressed by carefully planning the introduction of PBL by taking into consideration the motivational aspects that may affect the students. These motivational aspects include the organization of the course and the students' background because both can have an effect on students' perceptions of the course. Promoting a practical vision from the first stages of PBL is also one way to equalize and to reinforce students' interests. This planning should include the consideration of strategies to improve the students' problem-solving skills and other skills linked to project management, such as project planning, communication, and conflict management. It should also address the professional development of the facilitators; academic staff may not have the skills and the experience required to introduce PBL effectively. Perhaps by sharing findings such as those in the present study and teaching the facilitators about the MUSIC model and effective strategies to introduce active learning, facilitators could be even more effective in implementing PBL in ways that motivate students.

Acknowledgments—The authors want to acknowledge The Caja-Canarias Foundation, which supported this research through the "Research Projects 2014". Project ref. CSOCSED01: "Entornos de aprendizaje activo en el ámbito de la ULL como impulso a la empleabilidad y competitividad".

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