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Utilización de Aprendizaje Basado en Proyectos en la coordinación de asignaturas en el Grado en Ingeniería Agroalimentaria y del Medio Rural

Implementation of a Project-Based Learning to the coordination of subjects in the Agrifood and Rural Engineering Bachelor

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Resumen

El grado de Ingeniería Agroalimentaria y del Medio Rural de la Universitat Jaume I de Castelló viene aplicando en su segundo curso un proyecto multidisciplinar

Abstract

The Bachelor's Degree in Agrifood and Rural Engineering at Universitat Jaume I of Castelló has implemented in the second academic year a multidisciplinary

utilizando el Aprendizaje Basado en Proyectos como recurso docente en el que se pretende que los estudiantes adquieran competencias que les ayuden a enfrentarse a su futuro profesional. Este sistema de enseñanza-aprendizaje se ha llevado a cabo durante los tres cursos que está implantado el grado. Una vez asignado un tipo de explotación agrícola concreta y utilizando las herramientas del trabajo en equipo, los estudiantes deben ser capaces de desarrollar un proyecto sobre la explotación con propuestas de mejora que sean factibles y que abarquen aspectos relacionados con las diferentes disciplinas implicadas, aplicando los conocimientos adquiridos en éstas. El presente trabajo incluye los resultados obtenidos durante los tres años del proyecto desde dos puntos de vista importantes: la satisfacción del estudiante y los resultados de aprendizaje. Además se presentan las propuestas de mejora aplicadas en cada curso como respuesta a las debilidades detectadas durante el proceso. Los resultados demuestran que el método utilizado ha favorecido la adquisición de las competencias propuestas. Además, el enfoque multidisciplinar ha propiciado mejores resultados que los alcanzados por los estudiantes que realizaron trabajos unidisciplinares. Por otro lado, aunque las acciones de mejora han permitido solventar algunos de los problemas detectados, siguen persistiendo carencias, sobre todo a nivel de trabajo en equipo y de tutorización, que se proponen como mejoras para el futuro.

Palabras clave: aprendizaje basado en proyectos, proyecto multidisciplinar, trabajo en equipo, aprendizaje autónomo, ingeniería agroalimentaria.

project using a Project-Based Learning as the teaching method. Its final purpose is the acquisition of skills that should help the students to cope with their future career. This teaching-learning system has been used for three consecutive years since the degree was firstly implemented. Once a particular farm is assigned, the students are organized in groups and must fulfill their assigned tasks in a collaborative manner with the final goal of developing a project on that farm including viable improvements of the exploitation, taking into account the issues related to the different subjects involved. This work presents the results obtained along the three years, analyzed from two different points of view: student satisfaction and learning outcomes. Besides, the proposals for improvement of the weaknesses identified during the process are presented. The results show that the used method has promoted the acquisition of the competences proposed. Moreover the multidisciplinary approach has led to better results in the student performance than those obtained by students enrolled in an unidisciplinary project. Although improvement actions have solved some of the problems detected, there are still some weaknesses, mainly related to team working and tutorials that should be addressed in the future.

***Key words*:** Project-based learning, multidisciplinary project, team work, self-learning, agrifood engineering.

Introduction

Problem-Based Learning, firstly implemented in medical sciences in 1950's, is becoming a relevant method used in higher education programs, and in the last years is considered a strategic approach to university education (Rué *et al.,* 2011). This method allows students to understand and apply the acquired theoretical knowledge to real problems, and therefore to achieve the learning objectives (Branda, 2009). This teaching method may be also applied to engineering projects, known as Project-Based Learning (PBL) (Valero and Navarro, 2009). This model of learning, centered on the student, is oriented towards the design of projects that have an application in the real world beyond the classroom (Blank, 1997; Harwell, 1997). The PBL allows students to develop skills and competences such as collaborative work, communication, decision making, or time management (Dickinson *et al.,* 1998). They can also easily integrate different disciplines, enhance problem-solving skills, and field knowledge. This multidisciplinary approach is intended to force students organized in groups to work together in a collaborative manner on a problem that covers the competences of the different subjects involved (both general and specific) (Moursund *et al.,* 1997). When PBL is used, students take much more responsibility for their own learning, are increasingly more independent from their lecturers, and become independent learners who can continue to learn in their lifetime (Akınoğlu and Tandoğan, 2007).

Lecturers should become the students' guide, making suggestions and orienting them in their learning process. PBL makes students the main protagonists of their own learning process and the lecturers has to become the referee, providing the necessary guidance and making the adequate suggestions, but also establishing the limits and critically discussing both individually and with the whole group the solutions adopted (Velez, 1998).

In the present study we discuss our experience in this kind of PBL method that implies different subjects belonging to different disciplines. According to Rosenfield (1992) unidisciplinary approaches are studies that are initiated and continued within a single discipline whereas multidisciplinary researches occur when these researchers work sequentially or in parallel to each other on a topic but do so from their own discipline. Our study was carried out in an engineering degree, specifically in the Bachelors' Degree in Agrifood and Rural Engineering (DARE, henceforth) at Universitat Jaume I (UJI) with a multidisciplinary approach. This teaching method has been previously performed in engineering degrees (Kjersdam and Enemark, 1994; Nunes de Oliveira, 2011), and is highly challenging. Moving towards PBL requires at least three dimensions of attitudinal changes: one concerning the lecturers involved; one concerning the students' attitude towards learning; and finally, a change in the institutional culture (Nunes de Oliveira, 2011).

Regarding the lecturers attitudinal change, coordination is one of the most difficult issues to assess, despite the fact that coordination among subjects is an urgent need at university education. Time pressures, lack of communication, teaching overload and bureaucratic extra work, among others, are some of the reasons why coordination between lecturers is a complex task in real practice. The triple work profile of lecturers (teaching, research and management) (Buela-Casal and Sierra, 2007) is negatively related to lecturers efficacy and wellbeing (Vera *et al.,* 2010). Additionally, PBL demands that lecturers have educational skills different from traditional teaching abilities. The

presenter of knowledge role of the traditional lecturer should be changed to a promoter of learning role (Bouhuijs, 2011). From the point of view of students, who usually access Higher Education with limited, if any, experience of self-directed learning, a PBL experience is a challenge. They have to take responsibility for the learning process and engage in self-directed learning activities (Nunes de Oliveira, 2011). PBL can be extremely absorbing for lecturers, requiring high doses of involvement and commitment that affect other tasks (research and management). Therefore, the institution should play an essential role giving preference to teaching activities as an important factor for career progression, and strategic for the institution development (Nunes de Oliveira, 2011).

Nowadays the current economic and social situation is leading to a severe individualism, which, in turn, results in a crisis of values. A general purpose of a coordinated multidisciplinary project development is to provide students with the necessary tools to overcome this situation. On the one hand, we have pushed students to work in teams and cooperate. On the other, the different tools provided should allow them to develop new skills to solve current problems of agriculture and rural areas in a more sustainable way. Taken together, this should result in an enhanced entrepreneurship with a humanistic point of view. This approach is gaining attention in the education area, since the Theories of Global Change are demanding a global breakthrough conducted by organizations and individuals in terms of promoting the cooperation and sustainable development (László, 2004).

These days, working in teams is becoming a key issue. In fact, recent studies show that this way of working offers fruitful and exciting experiences and provides positive outcomes both for the organization and its members (Kozlowski and Ilgen, 2006; Wageman *et al.,* 2012). Moreover, new ways of teamwork appear through new technology development as virtual or globally dispersed teams (Maynard *et al.,* 2012) and even new software that facilitates the information sharing such as Google Drive (Llorens and Lapeña, 2014). Indeed, coordination, team working and new technology will pave the way of the education that builds students and people with commitment with the community and society. The way students will acquire these skills during their learning period at university will impact their future.

Additionally, it is known from previous experiences that coordination among subjects and lecturers involved in the same semester is necessary. In fact, during the latest years, it has been emphasized that many subjects are part of a single wider discipline and their distinction in subjects is purely formal. Such perception is sometimes difficult to be appraised by students, especially if subjects belong to different semesters or even academic years. Therefore, coordination is not just desirable but necessary (Buckley, 1998) for the global learning of a discipline. Otherwise, students can suffer from an overload of work. Moreover, competences and contents can result redundant if each lecturer tries to include them in every single subject separately. All these questions can seriously hamper the academic quality.

According to these coordination needs, a PBL was the method chosen for developing a multidisciplinary project to perform a holistic and multidisciplinary approach of the required competences of the second semester of the second year of DARE (Table 1). As the project was based on an existing agricultural facility that the students had to work on, our approach of PBL experience could be close to Action Based Learning (ABL), as according to Esteban-Guitart (2011) this kind of learning is associated with sustainable rural development

Table 1. General and specific competences of the four subjects of the second semester of the second year of DARE.

General competences	*Specific competences*
• Self-learning • Written and oral communication in native language • Knowledge of a foreign language • Environmental awareness • Information management • Critical reasoning	• Capacity to know, to understand and to use the different subjects considered • Capacity to know, to understand and to use the principles of decision making within the frame of a multidisciplinary group • Capacity to know the proper concepts of a company, institutional and legal framework of the companies, business organization and management

This PBL experience had to face with many challenges. The specific objectives were the following ones:

- To improve competences focused on practical work inside and outside the classroom/laboratories, such as cooperation and coordination, and entrepreneurship.
- To implement transversal competences from different disciplines.
- To enhance coordination between lecturers from different areas of specialization
- To make students conscious about the relationship existing between the different disciplines, as this will ensure their integral development as future professionals.

In a nutshell, the present work intends to show the coordination efforts that have been carried out during three consecutive academic years (2011/12; 2012/13; 2013/14) among four subjects of the second semester of the second course, namely: "Crop Protection", "Ecology and Environmental Impact", "Topography", and "Business" and the results of the implementation of a multidisciplinary approach in the student body of DARE at UJI.

Methodology

Contextualization

The implementation of DARE at UJI started in academic year 2010/11. The degree takes 4 years to complete (60 ECTS per year, 240 in total) and consists of five modules. The first module consists of 13 basic subjects (78 ECTS) which are delivered over the first and second year. The second module is common in the Agriculture branch (72 ECTS) and consist of 12 subjects during the second and third years. The third module is Specific Technology: Horticulture, Fruit Growing and Gardening (54 ECTS), and is structured in 9 subjects which are delivered over the two last years. The fourth module is made up of three optional subjects (18 ECTS) during the fourth year. On that year, the Degree Final Year Project (18 ECTS) should be presented. The main goal of this study plan is to train students within the university own program developed according to the principles of the European Higher Education Area (EHEA). To fulfill the requirements of this program,

it is necessary to adapt the contents, the competences, the methods, etc. used in each single subject of the study plan. As a consequence, during the academic year 2011/12, lecturers involved in the second course of DARE had to develop new methods to adapt the different subjects to the new academic model. This model includes a continuous evaluation of results.

A great effort of coordination among subjects, which implies coordination among lecturers as well, was encouraged from the very beginning of the implementation of DARE. However, coordination is not easy at university level. In the case of UJI, because of internal regulations ensuring the economic sustainability of the degrees, some subjects have to be shared among different degrees. That is the case of "Topography" and "Business", these two subjects are shared among different degrees related to engineering. Apart from that, "Topography" has traditionally based its learning on projects. Based on this way of working we decided to give a global vision to the second semester of the DARE by means of a multidisciplinary coordinated PBL that included initially (2011/12) three subjects "Topography", "Crop Protection", and "Ecology and Environmental Impact". "Business" was included later (2012/13 and 2013/14). All these subjects are included in the Agriculture branch module except "Bussiness", which is a basic subject. This multidisciplinary project covers a total of 24 out of 30 ECTS devoted to the second semester of the second course.

Development of the coordinated multidisciplinary project

The lecturers responsible of the different subjects involved and the coordinator of the second course of DARE met several times before the starting of the second semester. The goal of these meetings was to set the general criteria for the development of the project. These criteria were the following ones:

1. Distribution of the students enrolled in the different subjects considered
2. Group structure
3. Project formal structure
4. Execution calendar
5. Project evaluation
6. Student satisfaction and peer evaluation

1. Distribution of the students enrolled in the subjects considered

Two different categories were established. On the one hand, the students enrolled in the three (2011/12) or four (2012/13 and 2013/14) subjects considered (shared students) and, on the other hand, those who did not fulfill this criterion (non-shared students).

2. Group structure

Group size has been modified over time by reducing the number of the shared students that did the work (Table 2).

Table 2. Group structure of the three courses.

	2011/2012	***2012/2013***	***2013/2014***
Shared students	14 students split into two groups of 7	12 students split into two groups of 6	10 students split into two groups of 5
Non-shared students	12 students	42 students	47 students

3. Project formal structure

The project was centered on a particular farm, for instance an olive orchard or a tomato greenhouse. Students developed a guided questionnaire to obtain information from the owner or manager of the facilities studied and then they visited the farm. This field work allowed students:

- To take measurements that were used, later on, in the part of the project related to "Topography", *i.e.* for the case of tomato greenhouse, to design a new building including offices, storehouse, etc.

- To ask questions about residues produced at the facility that later on were used in the part of the project related to "Ecology and Environmental Impact", *i.e* residues management and its impact on the environment.

- To ask questions about crop protection practices that later on were used for the part of the study related to "Crop Protection", *i.e* apply an integrated pest management program for the tomato crop.

- To ask questions related to the organizational aspects that later on were used in the part of the project related to "Business", *i.e* analysis SWOT (Strengths, Weaknesses, Opportunities and Threats) of the organization.

Subsequently, students had to produce a written report and an oral presentation on the activities developed. Tutorial sessions between lecturers and students were organized to guide the activities and receive feed-back information.

The written report had a common introductory part about the agronomic, ecological and socio-economic aspects of the crop of the region where the farm was located. Further, each subject had a specific part including a material and methods and a results sections. Finally, a common conclusion for the three/four subjects completed the document. The inclusion of an abstract written in English was highly encouraged in the first academic year and was made compulsory in the following years.

A limited time allocated to the oral presentation was set and all students had to participate in the defense of the project. At the end, there was an open session for questions. Students had to answer questions formulated by the lecturer's team that were never directly related to the particular part of the presentation that each student had made. This decision was taken as a means of forcing students not to focus on one single part of the project but on the whole.

First year (2011/12), a course syllabus for each subject was prepared *ad hoc* and made available to students at the Virtual Classroom. These documents were presented in a session at the beginning of the second semester where the lecturers responsible of

the three subjects jointly presented the PBL. The following years several improvements were implemented according to the feed-back received from the students in the previous years. On the second course (2012/13), a unique course syllabus including all formal and content requirements of the project was developed. Moreover, in order to integrate this project into the Multilingual Plan of UJI, the use of English and the two official languages of UJI (Spanish and Catalan) was regulated in the written document and oral presentation. On the third course (2013/14), an "Information and Communication Technology" (ICT) tool was implemented. Google Drive was used by students and the lecturer's team for editing the project online. Further three common coordinated tutorials with all students and the lecturer's team were planned. A session especially devoted to work on social abilities was organized for the students at the beginning of the project. Besides, the students were offered a seminar that provided them information about the selected farms.

4. Execution calendar

The calendar for the different actions involved in this project during the three courses is presented in Table 3.

Table 3. Execution calendar.

Activity - actors	*2011/12*	*2012/13*	*2013/14*
Coordination meeting – responsible lecturers and coordinator of the 2nd DARE course	October and January	October and January	October and January
Project presentation – students and responsible lecturers	January	January	January
Seminar to acquire social abilities – invited speaker and students			January
Seminar on the selected farms – invited speaker and students			February
Development of a questionnaire to gain information about the selected farm - students	February	January	February
Field visit to the farm - responsible lecturers and students	February	January	February and March
Tutorials on demand - responsible lecturers and students	January to April	January to April	January to April
Common coordinated tutorial - responsible lecturers and students			February and April
Final coordination meeting – responsible lecturers and coordinator	April	April	April
Delivery of written reports – students	April	April	May
Internal evaluation of the reports with feedback to each group (possibility to fix problems detected) - responsible lecturers and students		April	May
Oral presentation and defense of the project - students	April	May	May
Evaluation meeting - responsible lecturers	May	May	May
Student satisfaction and peer evaluation questionnaires - students		May	May
Final project evaluation and final report- responsible lecturers, and the coordinator of the 2nd DARE course	May	June	June

5. Project evaluation

A common score was given by the lecturers involved for the common competences evaluated while a particular score was given by each responsible lecturer for the specific competences of each subject. Both scores depended on:

- The content and format of the written report and the oral presentation
- The follow-up activities during tutorials
- The answers to questions posed during the presentation.

The two marks were further combined into a single value where the common and the particular scores were represented 75 and 25% of the final mark, respectively. Therefore, a final mark for the project was given to each group as a whole. However, this final mark was weighted differently on each subject (30% of the final mark in "Business" and "Topography", and 15% in "Crop Protection" and "Ecology and Environmental Impact").

6. Student satisfaction and peer evaluation

The opinion of the students was important. A questionnaire was prepared and distributed at the end of the PBL experience. The information collected was used as feedback to identify strengths and weaknesses of the project, including peer evaluation. This assessment was not anonymous but confidential.

Results and discussion

The PBL teaching experience was analyzed from two points of view. First, the student satisfaction in the multidisciplinary project and its role as a player of a team was assessed. Second, it was evaluated the impact of the teaching method in the learning results by means of considering the project mark and final qualification.

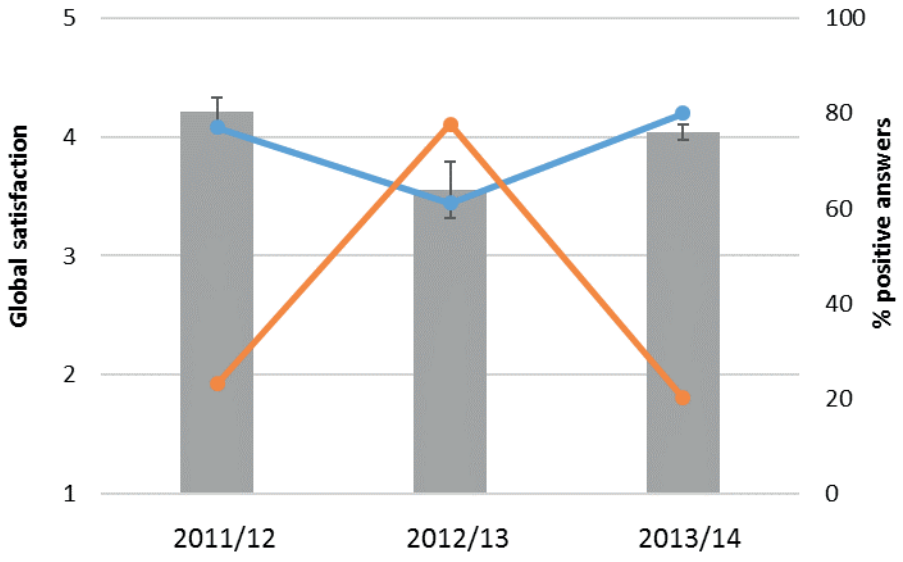
The tool used to evaluate student satisfaction and team role was a questionnaire. At the end of the teaching experience, the students answered a questionnaire about satisfaction with the method used and filled a peer evaluation of the work performed by their team mates. Answering this survey was compulsory for all the students enrolled in the project. The two first questions were closed-ended and nominal-dichotomous about the satisfaction with the teaching experience. The third one was an open-ended question where the students were encouraged to express suggestions to improve the PBL experience. The peer evaluation questionnaire contained 10 closed-answer items following the Likert scale. The issues dealt with the performance of the members of the group as participation, contribution to complete the tasks, discussions, capacity to solve conflicts and leadership. At the end of the questionnaire there was a section for expressing any comment and suggestion. The tool used to evaluate the acquaintance of the learning competence was the written project followed by an oral presentation. Furthermore, class assistance and active participation in all the activities proposed were also taken into account in the final evaluation.

Evaluation of the level of satisfaction of the PBL experience

This survey was answered by all the students who participated in the PBL experience: 14 (2011/12), 12 (2012/13), and 10 (2013/14). The number of students involved in the multidisciplinary project decreased because the degree was established in 2011/12 and in the following years not all the students were enrolled in the four subjects: 12 (2011/12), 42 (2012/13), and 47 (2013/14) students were not enrolled in at least 3 subject and had to work on an unidisciplinary project for the subjects that they took. The second and the third years, the number of students doing an unidisciplinary project increased because "Business" was included in this teaching experience.

The overall experience was rated by the students as satisfactory (4 out of 5), except for the 2nd year where student satisfaction was neutral (3.5 in the Likert scale) (Figure n.1). In this case, the number of suggestions made by the students highly increased and the recommendation to continue in the following years was reduced from 80% to 65% (Figure n.1). However, none of the students scored the experience as not satisfactory. Most of the comments and suggestions were positive and highlighted the value to assess a complete project similar as those that they have to face in their future career. Accordingly, Esteban-Guitart (2009), concluded that students found more pros than cons, based on the student perception after taking part in a PBL experience. In spite of the fact that our students also considered this experience positive, some drawbacks were pointed out, as lack of time for collaborative work, lack of training in group dynamics, and overlapping roles as observed by Sáez de Cámara *et al.* (2013).

Figure 1. Global evaluation of the student satisfaction (grey bar, 1 - 5 Likert scale), percentage of students who recommended this type of project for the future (blue line) and percentage of students who recommended changes for following year (orange line).



Student suggestions implemented through the academic years

The suggestions made by students to improve the PBL in the first academic year (2011/12) were focused on a higher coordination among the lecturers involved in the project and team size. One student even suggested single-person groups. Additional comments were

the need of a guideline and compulsory tutorials instead of tutorials on demand. Based on student's feedback, the changes included in the PBL experience were a new unified guideline, including temporal organization of the work, and compulsory tutorials that were included in the course syllabus.

In the second academic year, problems associated with team work were the main claim. Therefore, a session to work on social abilities at the beginning of the semester (2013/14) was planned. Team size, as demanded, was progressively reduced as the number of the students enrolled in the PBL experience decreased.

Finally, in the third academic year, a session focused on the suggestions proposed by the students in the previous year (2012/13) took place. This session was based on Belbin's team role theory (Belbin, 1981) and was addressed by a lecturer of the "Department of Evolutionary, Educative, Social and Methodological Psychology" (UJI). The topics dealt with assigning team roles and the importance of leadership, dealing with free-riders, signing a written agreement of commitment of the whole group and producing a book of acts including all meetings of the groups. Furthermore, the lecturer's team decided to implement an ICT tool by means of Google Drive (Llorens and Lapeña, 2014). The lecturer's team and all the students belonging to each team had editing access to this online tool. The aim of this tool was to track the progress of the project while the students were working on it.

These objectives were partly fulfilled. The session specially devoted to social abilities had a great impact on the students. However, they still had some problems with team roles, as in previous years, mainly focused on leadership. Only one of the teams produced a book of acts and none of them signed the commitment agreement. The ICT tool was not as effective as expected because students often worked offline. Only during the last weeks this tool was operative as students uploaded to receive lecturer's feedback.

Apart from that, three coordinated tutorials were organized with all students at the beginning, the middle and the end of the period of execution of the project. However, only two of these sessions took place, as the students did not attend the mid-session, as it coincided with a student strike.

Other issues that concerned the students were the topic of the project, team size, continuous assessment of the project, and, although a complete guideline was provided, students still had some doubts about what they had to do. Furthermore, students still complained about hitchhikers and couch potatoes that drag out the progress of the team. This topic is a usual complain when working in teams (Oakley, 2004).

Peer evaluation

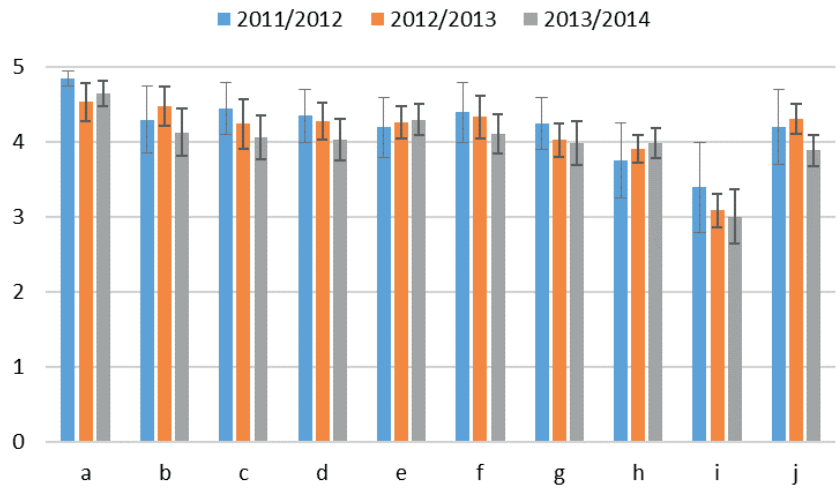
The peer evaluation of the work performed by their fellows was divided in two groups of issues: from "a" to "g" related to the project development and final results, and from "h" to "j" related to personal relationships among fellows (Table 4).

Table 4. Rated issues included in the peer evaluation of the project.

Student X....
• a: ...took part in the meetings
• b: ...contributed to the common tasks
• c: ...finished group assignments on time
• d: ...participated in the formal elaboration of the report
• e: ...actively discussed the contents of the report
• f: ...devoted time and effort to the project
• g: ...actively participated in the final edition and revision of the report
• h: ... got involved in solving conflicts
• i: ...acted as a group leader
• j: ...had a positive influence on the group

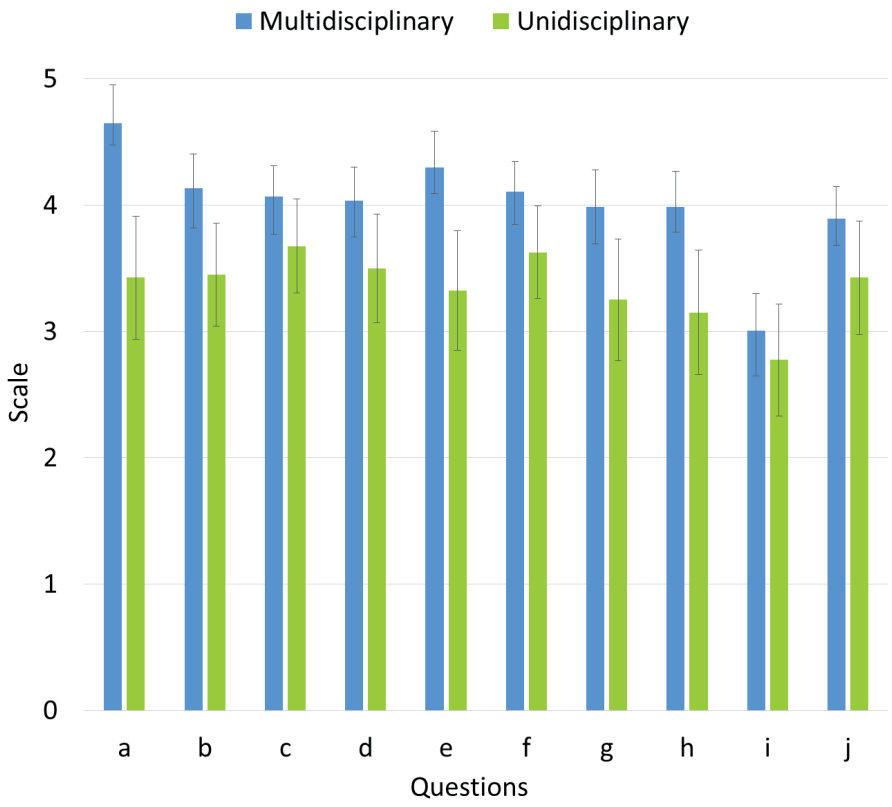
Main results of this survey are shown in Figure 2. Surprisingly, on the whole, there were no differences among years, despite the fact that in the last year (2013/14) students received a workshop on social abilities. Leadership (issue "i") was the lowest ranked question, especially last year. This could be the main reason why they had some conflicts among them. Leadership is a precondition for success, if leadership is weak, it could be too difficult to implement successfully a PBL strategy (Bouhuijs, 2011). Hersey *et al.* (2001) formulated some characteristics of leadership which were relevant for lecturers involved in this kind of experience. From the point of view of teaching, the important message stated by Bouhuijs (2011), is that leaders need to believe in why PBL is an answer to the problems of the institution, and to handle it accordingly. Something similar could be extrapolated to leadership among students. Proper leaders could motivate their fellows to move forward. Team leadership is critical to team success as leadership has to develop key functions, for instance, planning, communicating, problem solving, and decision making (Parker, 2008).

Figure 2. Results of the peer evaluation of the project. Issues "a" to "g" are related to the evaluation of the development of the project and "h" to "j" to personal relationships among group fellows in a 1-5 scale, where 1 mean "complete disagreement" and 5 "full agreement".



Last year of this teaching experience, students who could not enroll in the multidisciplinary project were also subjected to the same questionnaire, as they did an unidisciplinary work. With this additional sampling, we intended to know if a multidisciplinary project supposed an extra effort to students. In Figure 3, it is shown that students working in a multidisciplinary project better evaluated to their fellows than when working on a unidisciplinary project. This could be attributed to the fact that students were conscious that the responsibility in a multidisciplinary project is higher than in an unidisciplinary one, as the mark obtained was the same for all the subjects included in the project. Besides, multidisciplinary techniques are not only important for a student to learn any one single discipline or solve a problem in a synthesized manner, but it also enriches a student's lifelong learning habits, academic skills, and personal growth (Jones, 2009).

Figure 3. Results of the peer evaluation comparing the multidisciplinary and unidisciplinary project in 2013/14. Issues "a" to "g" are related to the evaluation of the development of the project and "h" to "j" to personal relationships among group fellows in a 1-5 scale, where 1 mean "complete disagreement" and 5 "full agreement".



Had working in a multidisciplinary project a global benefit on the students' works?

100% of students involved in a team work, both multidisciplinary and unidisciplinary projects, succeeded except for one student involved in an unidisciplinary project who did not attend he oral defense. On average, and considering all years, a mark of 7.6±0.1 was obtained for the multidisciplinary project and 6.8±0.4, for the unidisciplinary one

(Figure 4). Differences on marks were observed depending on the type of project. In general, higher marks were obtained for the multidisciplinary projects. In one of the subjects ("Crop Protection") this trend was maintained for all years (Figure 5).

Figure 4. Project marks and final marks at the first round of exams (mean ± standard error) for the three academic years considered.

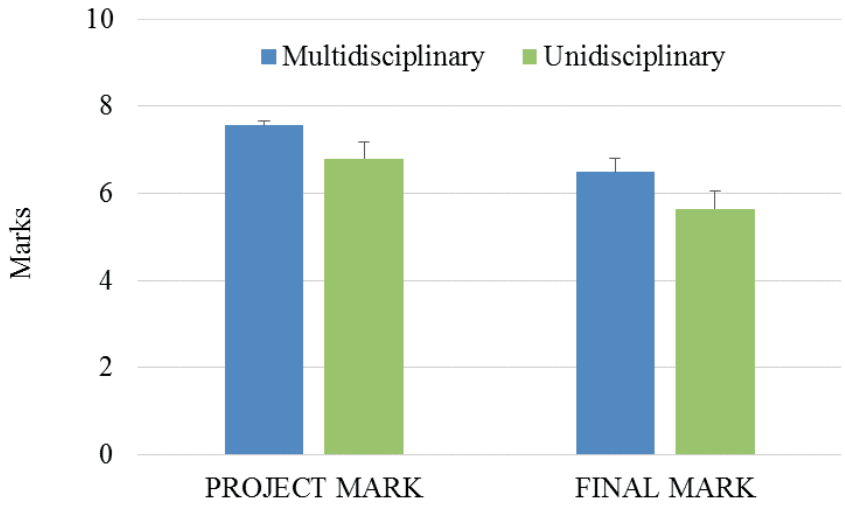
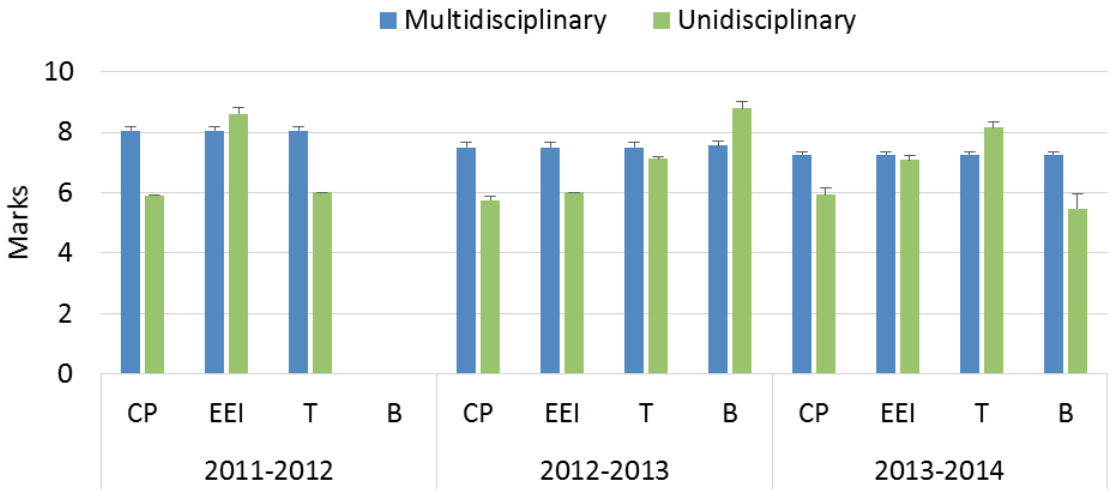


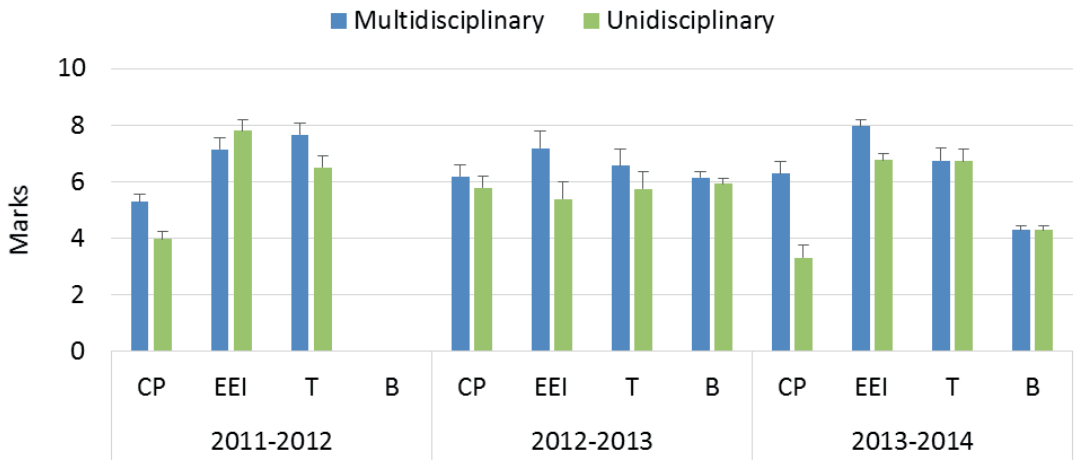
Figure 5. Project marks (mean ± standard error) for the three academic years and the four subjects considered (CP, "Crop Protection", EEI, "Ecology and Environmental Impact", T, "Topography", and B, "Business").



The differences observed for the marks in the first round of exams of each subject were in the same direction as the project mark (Figure n.4). Those students that had worked on the multidisciplinary project got higher marks. On average, and considering all years, a mark of 6.5 ± 0.3 was obtained for the multidisciplinary project and a mark of 5.7 ± 0.4, for the unidisciplinary one (Figure n.4). However, as each subject evaluated different skills, and the project (both multidisciplinary and unidisciplinary) was weighted differently for each subject, a higher mark in the project did not necessarily imply take a

higher mark in the global evaluation. In fact, there were students who did not pass one of the subject (Figure 6).

Figure 6. Marks in the first round of examination (mean ± standard error) for the three academic years and the four subjects considered (CP, "Crop Protection", EEI, "Ecology and Environmental Impact", T, "Topography", and B, "Business").



Our results show that students working on a multidisciplinary project in general obtained better results than those working on a unidisciplinary one, as observed in other engineering PBL experiences (Sáez de Cámara *et al.,* 2013). In addition, multidisciplinary project teams also offer many intangible benefits such as improved interpersonal skills, positive emotions and an increase in personal performance and motivation through working in multi-disciplinary teams (Ivins, 1997) as shown in Figure 2. Moreover, in an educational setting the experience of working in multidisciplinary project teams provides valuable encounter with the "real-world" pressures of delivering a project.

Conclusion and future prospect

The implementation of the multidisciplinary project in the 2nd course of DARE for three consecutive academic years has been an effective tool for both coordinated tasks development between the involved lecturers and the achievement of skills and competences of collaborative work and self-learning by students.

The PBL method has allowed us to detect some weaknesses in the learning process of the students which turned into challenges in the following courses. The students have positively scored the PBL experience by assuming the importance of collaborative and multidisciplinary work for their professional future. The final evaluation of the students highlighted that working in a multidisciplinary project yielded better results than in a unidisciplinary one. However the students' perception of a higher workload with this type of project needs to be solved. Furthermore, other factors not included in this study could be behind the results obtained. Therefore, further research is required during the next years to reaffirm or discard the results obtained.

Our results highlight that continuing with this teaching method in the next courses is worthy. However, there is room for some improvements:

- Team work: two workshops will be set during the scholar year (one during first semester and another one during the second) with the purpose of to further develop team working skills and project assessment.

- Role playing: Throughout the duration of the project, students must reflect the specific role developed by each team member in a book of acts as well as the progress of the project. These two aspects will be taken into account for in the project evaluation.

- Deliverable: In order to have a continuous assessment of the students during the implementation of the project, two pre-deliverables, one in the middle of the semester and the second one two weeks before the final presentation will be required. Both of them will be evaluable and will provide the lecturers actual information about the development of the work.

- Tutorials: the common coordinated tutorial sessions have proved to be a suitable tool to solve the doubts of the students and improve their reports. Therefore, the number of this type of sessions will be maintained in following academic years.

- Student feedback: new surveys will be designed to know about other aspects of the PBL experience, such as workload and acquired or reinforced competences.

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