

A Project-based learning for the subject “design and implementation of databases”

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Abstract

Project-based learning is a technique that uses projects to develop the learning process. This technique is being used in several matters and disciplines providing very good results. In this paper, a project-based learning is presented to improve learning in the subject: design and implementation of databases.

Students work in groups of four people. The activities are developed not only in the classroom (theory, problems and laboratory) but also as homework. Furthermore, during the project development, each group has to have individual interviews and discussion with the teacher to analyse the project evolution.

Despite the marks obtained in the project, where laboratory sessions, and the exam improve slightly the marks of previous year, it could be considered that the development of the project is very positive considering the improvement of the percentage of student's success. The enquiry developed at the end on the semester also shows that the project supports student in the learning process.

Keywords: *Project-based learning; Computer Science; Databases.*

1. Introduction

A database is a set of data stored in external memory that are organized by a data structure. Each database has been designed to meet the information requirements of a company or other organization, such as a university or a hospital (Marques, 2011).

In the Computer Science degree of University Jaume I, there are several subjects related to Databases. An introductory subject to databases is studied in the second semester of the first year. In the fourth year of the degree, students must choose subjects grouped in four subdisciplines of computer science: Software Engineering (SE), Information Systems (IS) Information Technology (IT) and Computer Engineering (CE). There are three different subjects that go deep in the databases matter. These subjects depend on the subdiscipline. Table 1 presents detailed information of these subjects, including credits, year, semester and type (compulsory or optional).

Table 1. Subjects directly related to Databases in the Computer Science degree of Universitat Jaume I.

Code	Subject	Subdiscipline	Credits	Year	Sem.	Type
EI1020	Databases	-	6	2 nd	2 nd	Compuls.
EI1038	Design and implementation of databases	IS	6	4 th	1 st	Optional
EI1041	Design of databases systems	SE	6	4 th	1 st	Optional
EI1052	Database management syst.	IT	6	4 th	1 st	Optional

Subjects EI1038 and EI1041 have the same curricula and competences, Thus, students of two intensifications share classroom, contents, teacher, lectures and evaluation.

In this paper, the work developed in both subjects are presented (henceforth, the subject is related to EI2038 and EI1041). The subject was designed and planned following the Bologna recommendations and the experience gained in the subject design and management of databases from the old degree of Computer Science.

This subject is studied in the first semester of the fourth year of the degree. In the subject, the design of databases is studied deeply, focusing especially on the logical and physical design of databases. In addition, the database design must be able to include the evolution of the information, turning it into an active database. The subject is structured in three types of sessions: theory, problems and practice in the laboratory. Theory and problems sessions are structured in 13 lectures of 1,5 hours' duration. Practice sessions are structured in 9 lectures of 2 hours.

The subject objective is to go deeper in the design and development of relational databases to model information systems. So, the main competences are: a) the ability to solve problems of information integration; b) the ability to integrate IT solutions and business processes and c) the ability to participate actively in the specification, design, implementation and maintenance of information systems.

2. Project-based learning

Project-based learning is a technique that uses projects to develop the learning process (Thomas, 2000). In the last 15 years, this technique has been used in several disciplines and education levels, especially in high schools and university degrees. Some examples were presented in Herper and Stahl (2003), Connolly and Begg (2003) and Nattasha and Azizah (2015).

Andrew Miller (2016), describes some basic tips to define PBL. These tips are: a) assess community needs, b) align content and skills, c) learn from each other, d) reflect often, e) create an action plan, f) evaluate the Impact, and g) celebrate Success. Valero-Garcia and Navarro (2008) identified three elements to define a PBL: a) the formation of project groups, b) the problem description and c) the student workplan and the learning objectives and competences.

Following these recommendations (tips and elements), a project-based learning approach has been used to develop the subject's activities (theory, problems and laboratory sessions).

3. A project to reach subject competences

In previous years, before the introduction of PBL, the activities that students had to carry out were not related between them, so that activities for the theory class were designed in order to understand more theoretical concepts, while activities for the laboratory class intends to apply these concepts in practice.

Currently, the PBL is the subject backbone, most of activities and lab practices are related to the project. Furthermore, homework, both individual and in group have to be done. The project consists in the complete design of a database for an enterprise, from the requirements description till the implementation in a real DataBase Management System. It is based on a real information system. However, in order to fit with the hours in the subject workplan, the information system has been reduced and it does not cover all the information system.

In 2018/19, the enterprise is focused on a private academy that offers courses of different matters and levels. The information system has to model the students, the different types of

employees, courses, exams, classes and timetables. Other information as accounting, sales... is not included in the project information system.

The project is developed in groups of three or four students. The group formation is free, only one rule has to be fulfilled: all group members must have, at least, one free hour in common during the week. This hour will be used, if needed, to hold physical meetings.

3.1. Project activities

During the development of the semester, students must develop 29 different activities (including lab activities). 8 activities and 2 lab sessions are basic learning activities used in the introduction of theory and lab sessions. The rest of activities are related to the project. 12 activities performed in the classes devoted to theory and problems, and 7 activities are practices which are performed in laboratory sessions. Table 2 shows the id number, the name and the description of the activities.

Table 2. Project activities. Activities are presented in chronological order.

Id	Activity	Description
5	Requirement description	The enterprise model is presented. The students perform the requirements of the information system.
6	Evaluation of requirements	Each group evaluates the requirements performed by another group. A rubric is provided. Finally, a common project requirements are agreed.
7	Conceptual design	Following the requirements identified in the previous activity, the conceptual schema is developed.
8	Evaluation of Conceptual design	Each group evaluates the conceptual schema of another group. A rubric is provided. Each group is able to work with its own proposal. Discrepancies are solved in the blackboard.
9	Logical design	The logical design of the conceptual schema is developed.
10	Evaluation of the logical design	Each group evaluates the logical design of another group. A rubric is provided. Each group is able to work with its proposal. Discrepancies are solved in the blackboard.
11	Physical design (CREATE TABLE)	The physical design is developed. Each group chooses the DBMS to implement the database (Oracle or PostgreSQL).
P2	Database Implementation	The designed database is implemented in one laboratory session. This activity is developed individually. Moreover, data has to be inserted in the database.
13	Views	A first approach of the possible database views are created.
P3	Triggers. Identity rules	A laboratory session is developed to control the integrity rules of the courses offered by the academy.
14	Modifying the model	A new computed attribute is added to one table. Then, the triggers to maintaining it always updated is developed.
15	Roles	Project roles are identified. Students must create these roles and manage the different user permissions.
P4	Triggers for auditioning	The updates performed in the employees of the academy have to be audited. New audit and historic tables are added to the model. Furthermore, several triggers are developed to maintain automatically these tables.
P5	Triggers. Business rules	This laboratory session is focused to develop different business rules (for example, to control the number of students engaged in the course). Each member of the group has to implement one different

		rule.
P6	External schemes and views	This laboratory session is an extension of activity 13. The final external schemes are implemented. Each member of the group has to implement different views.
16	Indexes	An activity to analyse the different indexes to make faster the database access is developed.
P7	Triggers.	More business rules have to be implemented using triggers.
P8	Triggers and views	In this laboratory session, students have to create triggers to make updatable the different views created in the external schemes.
20	Project document	In this activity, the group has to create a document including all the work developed during the course related to the project.

3.2. Project competences

The development of the project improves how students acquire the subject and degree competences, not only specific but also basic competences.

The specific competences are:

- The ability to solve problems of information integration is trained in the whole project, but specially in activities 5 and 7 where the problem is analysed and defined.
- The ability to integrate IT solutions and business processes are reached in activities and practices, where specific processes are proposed and solved.
- They acquire too the ability to participate actively in the specification (activity 5 and 6), design (activities 7-11), implementation and maintenance of information (activities 11-16 and practices).

The basic competences are:

- Synthesis and analysis capacity. This basic competence is acquired in all activities, but mainly in activity 5 and 7 where the analysis and scope of the project is defined.
- Problem resolution. The whole project implies to know how to solve a problem. Furthermore, activities 7, 9, 11 and practices stimulate this competence.
- Autonomous learning. The project encourages the autonomous learning and critical thinking in two ways: a) Students must provide their own solutions in different activities, so they have to look for and propose new problems solutions

and b) some activities are evaluated by other groups, so students learn, from other students, different problem solutions.

Furthermore, during the development of the project activities, students work with different software tools to model, design and implement the database. In concrete, to develop the conceptual model students use *Dia*. To develop the logical design, they use *Vertabelo* software and finally, the database could be implemented in *Oracle* or *PostgreSQL*.

3.3. Project assessment

The project assessment is done during all the semester. The deliverables and results developed by each group (related to different project phases), are evaluated in several ways: a) common review, where activities are corrected in the blackboard; b) a peer review, where groups analyse and evaluate the results provided by other groups (blind review) and c) individual group review, where the teacher corrects and guides individually the different groups.

At the end of the semester, the final mark of the project is calculated following next rules:

- The teacher provides a final project mark (TM). This mark has a weight of 60%.
- The other 40 % is calculated based on the teacher mark, but also considering the own student's evaluation.

4. Results

Table 3 presents the arithmetic mean marks of the subject from 2017/18 and 2018/19 years (first call). Data are presented for the whole subject and individually (EI1038 and EI2041). The marks presented are for lab sessions, project, exam, theory activities and final marks. Moreover, a column indicating the students enrolled and the percentage of students that pass the subject is also presented in the table.

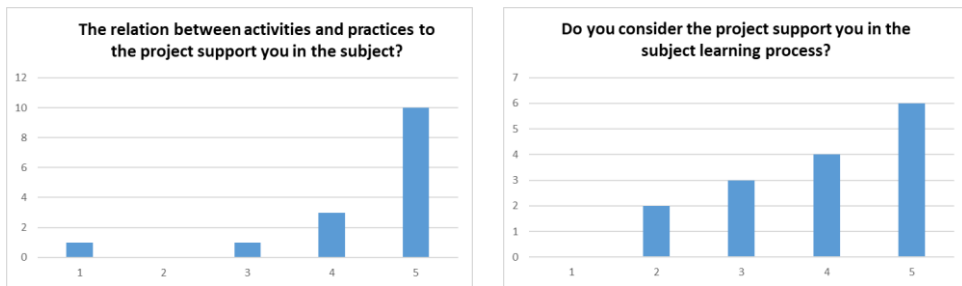
The results show slight improvements. Laboratory and the project are only increased by decimals. Even more, in EI1042 the project mean mark has decreased with the new project. (8,14 vs 7,83). However, the exam and the final mark is increased by 1 unit. The most important result is the percentage of success, the student that pass the subject has been increased significantly.

Table 3. Mean of marks of activities for academic years 2017/18 and 2018/19. Note that final mark is not the addition if the others because it depends on percentage of weights and minimum marks to success.

Subject	Year	Lab	Project	Exam	Theory	Final	Students	Success
EI1038-41	2017/18	8,23	7,91	5,23	9,73	7,69	35	65,7 %
	2018/19	8,34	7,98	6,20	9,68	8,00	25	78,3 %
EI1038	2017/18	8,02	7,35	4,10	9,60	7,13	10	30,0 %
	2018/19	8,38	7,98	5,24	9,64	7,74	7	57,1 %
EI1041	2017/18	8,32	8,14	5,69	9,79	7,78	25	78,3 %
	2018/19	8,32	7,83	6,61	9,70	8,07	16	87,5 %

Nevertheless, two main issues have to be considered with these data: a) there are only one year before and after the PBL deployment and b) the samples are different, not only in number of students, but also in the students' themselves.

This year, once students finished the subject (and they know their marks), an enquiry was done to know their opinions about the subject and the project. 66 % of students answered it (15 students). The results are very positive: major part of students agree that the project is very useful and support them to acquire the subject concepts. Graph 1 presents the results of questions 5 and 6 related to the project and how it improves the subject learning process.



Graph 1. Student's enquiry. Results of question 5 and 6. ("1" imply disagree vs "5" agree).

Furthermore, they also agree that the project is realistic and with an adequate complexity to be developed during the course. The homework time for the project is also considered appropriate. All students consider that the activities are well described and related to the project.

5. Conclusions

Project-based learning is a technique used to do more attractive the learning process. Students acquire knowledge competences and skill working in a project during the subject. In this paper, a project-based learning has been presented for the subject design and implementation of databases.

The project consists in the complete design and implementation of the information system of an enterprise. Most of the activities and laboratory sessions were changed and adapted to the project. Thus, the subject is focused on the project development.

The results are very positive and promising, specifically the percentage of success. Furthermore, students were motivated developing good work habits not only in the sessions but also in their homework. These questions and doubts were used in sessions to improve the activities and the general knowledge.

However, there is room for project improvement. Next year, some modifications will be prepared, taking into account this years' experience and the student's comments. So, all laboratory sessions will be related with the project, modifications and updates of the activities will be developed, and two workshops will also be developed, one at the beginning to explain the project and one near the end of the subject to detail the final task to present the final version of the project.

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