Chapter #13

DO YOU STUDY OR WORK?
Project based learning as an enriching experience in education

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ABSTRACT
Project Based Learning (PBL) is a very popular teaching strategy nowadays because it offers a great number of advantages and/or opportunities from a teaching point of view, such as achieving a deeper learning, developing teamwork and leadership skills, or getting the student to take control of what and how to learn. For all these reasons, the authors believe that, in the context of the Master's studies, as the last studies before insertion into working life, the PBL can be a very appropriate teaching methodology, since well thought out it will prepare students for the real situations that they will later experience in their professional lives. The objective of this work is to present the experience of the application of PBL in the development of a common project for four subjects of the University Master in Engineering, Processing and Characterization of Materials, taught at the Polytechnic School of Alcoy, belonging to the Polytechnic University of Valencia (UPV).

Keywords: project based learning (PBL), teamwork, active learning.

1. INTRODUCTION

Project Based Learning (PBL) is a growing teaching strategy in which students, combined in groups, carry out projects based on real situations.

In the framework of the European Higher Education Area (EHEA), learning is centered on the student. The contents are given a second priority since what really matters is the need to teach how to learn and the methods used to do so. The objective is to prepare the new generations for continuous learning (Reverte Bermabeu, Gallego, Molina-Carmona, & Satorre Cuerda, 2007). In this new paradigm, the PBL offers us a series of advantages and/or opportunities among which it is necessary to stand out:

- It produces a deeper learning in students.
- It makes the students become the main protagonists of their own learning process.
- It promotes teamwork and leadership.
- It changes the teaching approach focusing on the development of skills and not on the memorization of knowledge, which will result in a better preparation of students for working life.
- It generates an active and dynamic teaching environment where teachers and students interact and there is a way for feedback, which in the end generates an improvement in learning.

For all these reasons, PBL has awakened a lot of interest in teaching, not only in the area of higher education, but at different educational levels (Donnelly, 2017, Li & Tsai, 2017; Joshi, Desai, & Tewari, 2020; Chen, Kolmos, & Du, 2021).

De Graaff and Ravesteijn postulate that PBL allows for the development of teamwork, problem solving and leadership skills, within a framework in which the student takes control of what and how to learn (De Graaff & Ravesteijn, 2001).

On the other hand, Schön suggests that, in the work environment, engineers reflect in action, so the skills needed to acquire to do this cannot be taught in the classroom or in the laboratory, using only scientific theory, but carrying out a design study (Schön, 1987).

For all these reasons, authors believe that, in the context of Master's studies, as the last studies before insertion into working life, since few students decide to try to get a doctorate, Project Based Learning can be a very appropriate teaching methodology, since well thought out, among many other things, it will prepare students for the real situations that they will later experience in their professional lives.

The objective of this work is to present the experience of the application of PBL in the development of a common project for four subjects of the University Master in Engineering, Processing and Characterization of Materials, taught at the Polytechnic School of Alcoy, belonging to the Polytechnic University of Valencia (UPV).

2. BACKGROUND

Four compulsory subjects have been selected from the University Master's Degree in Engineering, Processing and Materials Characterization. Table 1 shows the subjects selected, as well as the semester in which they are taught and their teaching load. As these are compulsory subjects, it is guaranteed that all students will take them.

Table 1.
Subjects involved in the PBL project.

Subject	**Semester**	**Teaching hours (Theoretical + practice)**
Structure and techniques of characterization of advanced materials	1st	30 + 30
Research methodology	1st	25 + 20
Non-conventional techniques for forming and joining materials:	2nd	25 + 20
Diagnosis and in-service behavior	3rd	25 + 20

It should be noted that each course the number of students registered on this Master's tends not to exceed 25 and that in general the academic performance is above 90%.

3. OBJECTIVES

The general objective proposed by the authors is that the students, combined in groups, develop new products made with advanced materials. This will require the complete characterization of these materials. The idea is to approach and work on the contents of the two main parts while developing the different phases of the proposed projects.

3.1. Specific objectives

On the other hand, the specific objectives proposed to the students are:

- Propose a possible new product that needs to be made with advanced materials.
- Formulate a new product with advanced materials.
- Develop a new product with advanced materials.
- Characterize the advanced materials used in the new product.

With these specific objectives it is intended that students acquire the following competences:

- Development of innovation, creativity, and entrepreneurship.
- Development of teamwork and leadership.
- Development of ethical, environmental, and professional responsibility.

4. IMPLEMENTATION OF PROJECT BASED LEARNING

It is proposed to structure learning through a common project that includes all the aspects and knowledge to deal with the four subjects.

To this end, the authors initially proposed to modify the training programme of the four subjects in the dimensions of curriculum design, curriculum development and curriculum evaluation, in order to achieve curriculum alignment, and to this end the following questions were posed: What to teach? How to teach? When to teach? What, how and when to evaluate?

The answer to "What to teach?" can be answered from the following driving question proposed to the students: "Am I able to develop and fully characterize a new product with advanced materials", as well as from the specific objectives proposed to the students listed in the previous section.

As for the “How to Teach?”, the PBL is the methodological and didactic strategy that determines the activities and the necessary resources, but in a general way, the following types of activities and teaching tools have also been used:

- Puzzles: They are used to help students learn the theoretical topics. The topics to be studied are distributed within each group of students. Then each member of the group takes the role of teacher, explaining to the rest of the group members the topic he has to study and making sure that all the members of the group learn well the topic in question, which he first studied. At the end all the members of the group have played the role of teacher and student, and all the topics will have been learned. On the other hand, for the study of the topics the students have a wide repertoire of teaching material prepared by the teachers responsible for the subject, including the learning objects of Teaching on the Net (Media repository, Teaching Articles, Screencast, etc.).
- Expository Classes: It is necessary to give a limited number of them to solve doubts that arise during the project. They are of short duration and only aimed at solving the problems that arise during the development of the project, at the appropriate stage.

The question "When to teach" requires the teachers responsible for each subject to establish a detailed weekly work plan, which contemplates the activities to be carried out with reference to the different groups, the dates to complete the different stages, etc.

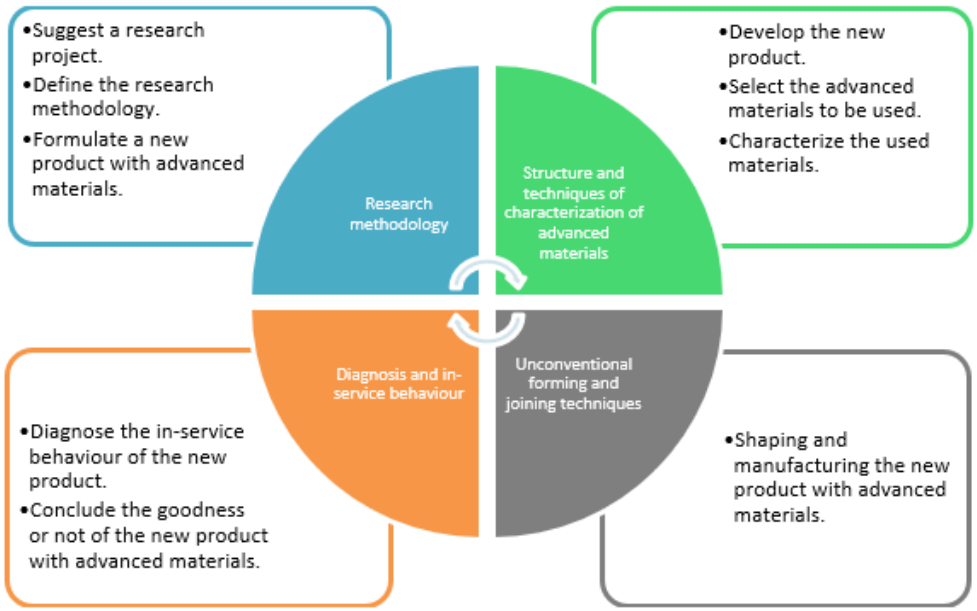
And finally, as for "What, how and when to evaluate?", the evaluation tools used have been the following:

- Self-evaluations. These are individual exercises on the project's topics that the student must self-evaluate. For this purpose, there is a list of conditions to check, such as: What would happen if..., What difference is there between ... and ..., etc.
- Peer evaluation. Each group of students will evaluate two other groups in each of the subjects. For peer evaluation, students have a rubric prepared by the teachers responsible for the subject.
- Tests to verify the acquisition of knowledge using the Kahoot tool.
- Partial deliveries.
- Deliverable and final public defense.

After several brainstorming sessions by the teaching staff, different products, parts and assemblies with a high technological content are proposed, incorporating the most advanced designs, calculations, manufacturing processes and materials in the field of engineering, to be presented to the students as examples of possible projects to be developed. This does not mean that students cannot make their own proposal, which must be approved by the teaching staff to ensure that the proposed product needs to be worked on and developed in the four areas involved.

Figure 1 shows a schematic view of the contents of the four subjects to develop the project. The next step was to carry out a detailed planning covering all aspects and from which each of the steps to be taken were derived, which addressed in great detail the methodological development of the innovation.

Figure 1.
Relationship between the subjects in the PBL project.



For each subject, a detailed weekly planning has been made, which includes all the partial objectives, contents, tasks, aspects to be dealt with, etc., for the development of the PBL. In this planning the teachers have also considered the development of the competences

of each subject and the transversal competences that are developed when carrying out work that involves several subjects. The development of the proposed project represents approximately 40% of the time of the subject "Research methodology", 50% of the time of the subject "Structure and techniques of characterization of advanced materials", and 30% of the time of the subjects "Non-conventional techniques of forming and joining materials" and "Diagnosis and behavior in service".

An example of a product developed in these subjects is a biodegradable gastroenterological stent made of polylactic acid (PLA), a biodegradable polymer. Halloysite nanotubes are added to the polylactic acid and serve as nano-containers for the controlled release of drugs (antibiotics, anti-inflammatories, etc.). Through the subjects "Research methodology" and "Structure and techniques of characterization of advanced materials" the research project is proposed, advanced materials are defined and characterized. Using additive manufacturing techniques for 3D printing, in the subject "Non-conventional techniques of forming and joining materials", the prototypes of these "stents" are developed. And finally, in the subject "Diagnosis and in-service behavior", tests are carried out to evaluate their behavior. One of the members of the group. One of the members of the group is currently doing a doctoral thesis developing this initial work in more depth.

5. RESULTS

The experience of applying project-based learning in the subjects of the master's degree is being developed from the 2018-2019 academic year. Since these are subjects from three different semesters, a generation of students have already completed these subjects. The results achieved after the application of the Project Based Learning methodology have been very satisfactory. Not only have 100% of the students who have followed the subject managed to pass it, but also a higher degree of knowledge acquisition has been achieved, which translates into average qualifications generally higher than those of previous courses.

But in order to get the students' opinion and their attitude towards the new methodology applied, a questionnaire was carried out and completed by all the students. Table 2 shows the questions and the results obtained.

Table 2.
Questionnaire made to students to determine satisfaction.

1	What type of teaching methodology would you prefer to use in the classes?	PBL - 100 % Traditional method - 0 %
2	Have you previously had other subjects in which project-based learning will be used?	Yes - 58.3 % No - 41.7 %
3	Do you think it would be interesting that more subjects of the Master will be coordinated in the common project as a central axis of learning?	Yes - 100 % No - 0 %
4	Were the objectives of the project clear and concise from the beginning? 1 - Neither concise nor clear 5 - Very clear & concise	1 - 0 % 2 - 0 % 3 - 8.3 % 4 - 25.0 % 5 - 66.7 %

5	In the subjects affected by the project, were the planning, duration, and management of the proposed project adequate? 1 - Not adequate 5 - Adequate	1 - 0 % 2 - 0 % 3 – 0 % 4 - 16.7 % 5 - 83.3 %
6	Do you think that the realization of a project has been useful to obtain knowledge about the subjects that you consider that you would not have achieved through traditional teaching?	Yes – 91.7 % No - 0 % I'm not sure - 8.3 %
7	Would you recommend this type of teaching to other students?	Yes - 100 % No - 0 % Maybe - 8.3 %
8	Do you think you have learned more with this new type of methodology than in classes where a traditional method is used?	Yes – 91.7 % No - 0 % I'm not sure - 8.3 %
9	Do you think you have become more involved in this subject because of the type of methodology used than in others with a traditional methodology?	Yes - 100 % No - 0 %
10	Are you satisfied with the project? 1 - Not at all 5 – Very satisfied	1 - 0 % 2 - 0 % 3 - 0 % 4 - 33.3 % 5 - 66.7 %

Analyzing the students' answers, a series of very enriching conclusions are drawn for the teaching activity of the teachers involved in this methodological change, since:

- In general, the students are very satisfied with the PBL methodology applied.
- The objectives, planning, duration, and management of the project have seemed adequate to them.
- Most of the students think they have learned more and better than with a traditional teaching method.
- All the students think that their involvement in the subjects has been much greater with the application of the PBL methodology.
- And finally, all the students say that it would be interesting to add more subjects from the Master's degree in the common project, this being the intention of the teachers involved in this project.

6. CONCLUSION

As mentioned above, the academic results of the students can be considered very good after the application of the Project Based Learning methodology in a common project of several subjects of the Master. The 100% of the students who have followed the subject have managed to overcome it and also have registered average qualifications generally higher than those of previous courses.

On the other hand, the opinion questionnaires given to the students show not only that they like this methodological tool, but what is more important, their feeling that they have learned more, better and with a higher degree of involvement.

As a final conclusion, although we think that the PBL cannot be a magic recipe that can be used for everything, and that it may not have good applicability in certain subjects, for many others it does, and the fact of combining several subjects of the Master in a common project allows the knowledge of the different subjects to be interrelated. And in fact, the PBL

methodology should also be implemented progressively in the engineering grades, so that, especially in the last years, it would have a greater weight in the students' activity, since this type of methodology, apart from the many advantages it promotes, listed in the introduction, it really prepares students better for their insertion in the working world.

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