

PILOT IMMERSION OF UNDERGRADUATE STUDENTS IN THE SCIENTIFIC METHOD BY APPLYING FOR A RESEARCH PROJECT IN A SIMULATED CALL FOR PROPOSALS

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Abstract

This work describes an educational innovative experience that includes a combined Project Based Learning and Simulation Based Learning activity (PBL and SBL, respectively). The experience has been carried out during the first semester of the academic year 2022-2023, within the compulsory subject of Instrumental Analysis, that is taught to the second-year students in the bachelor's degree of Pharmacy at Universidad Complutense de Madrid. According to the proposed methodology, the students took as their starting point the idea of developing a new analytical method to quantify a compound of their own interest present in food, pharmaceutical, clinical or environmental samples. To this aim, they prepared a proposal and applied for a research project in a simulated call for proposals that was launched by teachers on the virtual campus of the subject. At the end of the semester, a posters session was held where students were invited to present their work as similar to a research diffusion event. This session was also used by teachers as a debriefing session.

Scientific knowledge can be expressed in multiple formats, but for a scientific work to be considered as such, it must conform to certain formal and methodological characteristics that guarantee its rigour. The main objective of the activity is to familiarise students with the usual format of scientific documents, to make them aware about how to prepare a proposal with bibliographic support and to develop oral and written communication skills that they will need in their professional development and, in the near future, in the preparation of their Degree and Master Final Works.

The activity was designed as a complementary task to the syllabus of the subject. 46 students from two course groups voluntarily participated in the activity (45% of total students) and 13 proposals were submitted. The poster presentation and debriefing session were especially participative and provided an opportunity for students to develop critical thinking by judging their own posters, as well as the posters of the others. Teachers valued the activity as a promising tool for the competence development of the students, that encourages faculty as active-learning environment designers.

Keywords: Research projects, Project Based Learning, Simulation Based Learning, Teamwork, Communication Skills.

1 INTRODUCTION

The European Higher Education Area (EHEA) has brought about a methodological change in the teaching-learning process that affects the implementation, by the teaching staff, of active learning activities, through which the development of students' competences is encouraged. Project-based learning (PBL) is a methodology in which students construct a final product by using research strategies [1]. Although the concept is not new and the term was coined as such in the 70s and 80s of the last century, today it is an educational tool of full validity, as it is one of the active methodologies that can offer a better response to the methodological change proposed in the framework of the EHEA [2], [3]. The methodology has recently been reviewed in the field of higher education, showing its high degree of applicability in STEM (Science, Technology, Engineering and Mathematics) disciplines [4].

Another important aspect of the EHEA is to make students the protagonists of their learning process and a good way to achieve this goal is to place them in learning environments that facilitate their autonomy with respect to the teacher [5]. Simulation activities (SBL) place the students in a professional working context. However, for a simulation activity to be truly formative and complete, it should end with a debriefing session conducted by the teacher, that pointed out the learning objectives and their degree of achievement.

The report of the Pharmacy Degree verified by ANECA (National Agency for Quality Assessment and Accreditation of Spain) includes in the Analytical Chemistry block different general and transversal competences related to scientific knowledge and which refer to its production, communication, diffusion and critical evaluation. Scientific knowledge can be expressed in multiple formats, but for a scientific

work to be considered as such, it must conform to certain formal and methodological characteristics that guarantee its rigour. In written documents, it is necessary to observe an appropriate use of language and to follow a series of formatting rules established according to the type of text and the purpose for which it was written. The text must follow a coherent discourse, which gives a systematic presentation of the work [6]. In this sense, the structure adopted internationally is the so-called IMR&D (Introduction, Methodology, Results and Discussion), which may be slightly modified depending on the type of document in question (scientific article, project, thesis, etc.) [7].

In this context, a combined PBL and SBL activity has been carried out in order to familiarise students with the usual format of scientific documents, to make them aware about how to prepare with bibliographic support and to develop soft skills such as teamwork and oral and written communication that they will need in their professional development. Besides, oral and written skills will be crucial in the near future in the preparation of their Final Degree and Final Master Projects.

2 METHODOLOGY

A combined PBL and SBL activity has been proposed in which students have applied for a research project in a simulated call for proposals. This active methodology has been carried out during the first semester of the academic year 2022-2023, within the compulsory subject of Analytical Chemistry II (Instrumental Analysis), that is taught to the second-year students in the Pharmacy Degree at Universidad Complutense de Madrid. Figure 1 indicates the timeline followed for the activity development.

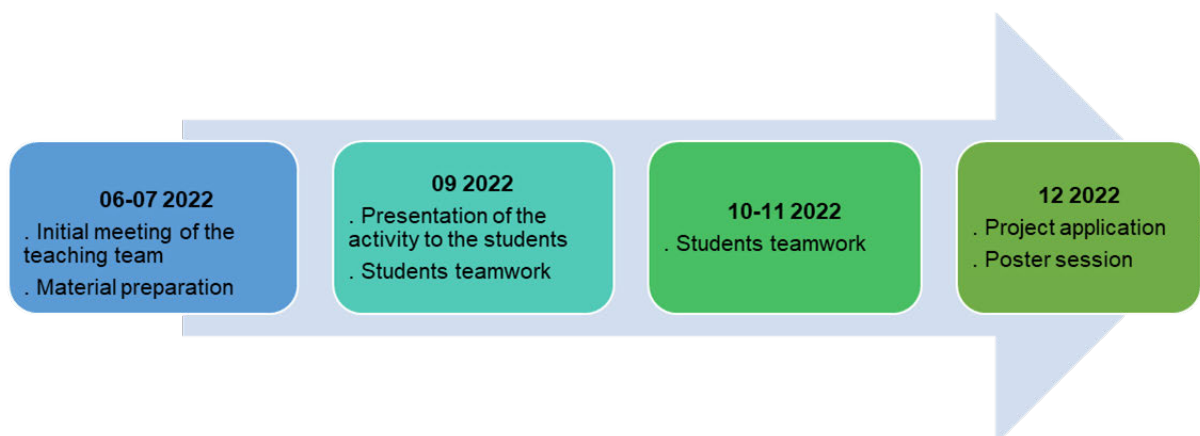


Figure 1. Working plan carried out.

2.1 Project Based Learning component

The students divided themselves into working teams. Each team took as their starting point the idea of developing a new analytical method to quantify a compound of their own interest present in food, pharmaceutical, clinical or environmental samples. To this aim, they wrote a proposal and applied for a research project in a simulated call for proposals that was launched by teachers on the virtual campus of the subject. The proposal consisted of a document including Title, Acronym, Authors, Keywords, Introduction, Objective and References. The introduction should follow the next outline: What is the selected sample and analyte? Why is relevant its determination? Which are the most common analytical methods currently used for its analysis? The objective was the same for all groups and consisted of a paragraph stating the idea that the students wanted to develop an alternative analytical method to the existing ones, justifying the advantages of the proposed method. For the activity to be successful, it is important that it was sized realistically. The proposal must not be focused on its length, but in its quality, with a recommended maximum length of 3 pages. Once the proposals were submitted, the students prepared a poster to present their ideas in a poster session that was held at the end of the semester. The poster included Title, Authors, Introduction, Objective, Materials and Methods, Results and Discussion, Conclusion and References. The Introduction, Objective and References sections were the same as in the proposals, whereas Materials and Methods, Results and Discussion and Conclusion were taken from the principal bibliographic reference as an example of analytical method and its application.

2.2 Simulation Based Learning component

Teachers launched a call for proposals on the virtual campus of the subject. This call was arranged to be as realistic as possible, with the phases and tools of an official call. That means that the call was announced in advance and a special section was opened on the virtual campus of the subject where students had got at their disposal a document with the rules of participation, instructions and deadline for submission, as well as templates for filling the proposal and the poster. Finally, the students submitted their proposals by using the tool *task* provided by the virtual campus program. At the end of the semester, the teachers hosted a public poster exhibition session, which served as both closing and debriefing session.

3 RESULTS

The activity was designed as a complementary task to the syllabus of the subject. 46 students from two groups voluntarily participated in the activity, representing 45% of the total number of students enrolled in the two groups. Considering that the activity was a voluntary task, the level of participation was positively valued by the teaching staff.

The students formed the working teams spontaneously. The teams had to be composed of a maximum of 5 members. In summary, 3 groups of 2 members, 2 groups of 3 members, 6 groups of 4 members and 2 groups of 5 members were formed, resulting in 13 proposals that were submitted. The programme of the Instrumental Analysis course focuses on the study of spectroscopic, chromatographic, mass spectrometry and electrochemical analytical techniques. The students were free to choose their topics of work. The selected topics were varied and covered 90% of the taught syllabus. Table 1 shows the distribution of topics chosen by the students, indicating the analytes under study, the type of sample to be analysed and the main analytical technique used in the reference articles with which they prepared their posters.

Table 1. Summary of topics chosen by the students with indication of the compound under analysis, sample studied, and analytical technique applied.

Topic	Analyte	Sample	Analytical Technique*
Environmental analysis	Lindane	Soil samples	GC
Environmental analysis	Microplastic	Fishes	HPLC / IR spectroscopy
Environmental analysis	Leachate elements	Volcanic ashes	ICP-OES
Food-stuff analysis	2-Ethylhexanoic acid	Glass jar-packed food	GC
Food-stuff analysis	Biphenyls contaminants	Soft drinks	GC
Food-stuff analysis	Anabolizing agents	Nutritional supplements	GC
Food-stuff analysis	Synthetic Dyes	Sports drinks	HPLC
Food-stuff analysis	Mycotoxins	Food products	HPLC
Food-stuff analysis	Amygdalin	Almonds	HPLC
Food-stuff analysis	Mercury	Canned tuna	EAAS
Biomedical analysis	Cortisol	Biological fluids	HPLC
Biomedical analysis	Tianeptine	Human plasma	HPLC
Biomedical analysis	DNA	Genome	OGM

*GC: Gas Chromatography; HPLC: High Performance Liquid Chromatography, IR spectroscopy: Infrared Spectroscopy, ICP-OES: Inductively Coupled Plasma Optical Emission Spectrometry, ETAAS: Electrothermal Atomic Absorption Spectrometry, OGM: Optical Genome Mapping

The teachers evaluated both formal and content aspects of the proposals and the posters. The evaluation of the activity was not based on numerical marks, but each team received personal feedback from the teachers. The evaluation of the proposals considered the selected topic and its justification, as well as the adaptation of the text to the script proposed in the instructions of the call, the quality of the bibliographic references and that these references were correctly inserted in the text and referenced following a recognized citation model (APA, Vancouver, etc.). Regarding the posters and in addition to the adequacy of the content to the template provided, special attention was paid to the design, the use

of the space, appropriateness of tables and figures and that these elements included table headers and figure captions, respectively.

The poster session was particularly participative and was used by teachers to assess oral communication skills. The wide variety of topics chosen by the students proved to be particularly useful as it gave an overview of the main content of the subject. In the session, the students were invited to assess their own work and that of the others, which resulted in a good exercise in critical judgment. In general, they pointed out that carrying out the activity and their participation in the poster session was a very positive experience.

Finally, the teachers were very satisfied with the development of the activity. Once its formative character has been verified, to introduce the activity as a mandatory task with a specific mark in the program of the subject is considered for the next courses.

4 CONCLUSIONS

The proposed active methodology based on the combined use of PBL and SBL:

- Has proven to be a good tool to introduce students to the use of the format IMR&D, of general application in scientific reports.
- Has made students understand that no scientific research starts from zero, but it is based on existing prior knowledge. It has also made them aware about the importance of correctly referencing the bibliography in scientific papers.
- Has proven to be a good tool for developing soft skills such as oral and written communication skills and teamwork.
- Has encouraged teachers as active-learning environment designers.

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