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PROBLEM-BASED LEARNING, PBL AND TEAM-BASED LEARNING, TBL APPLIED TO UNIVERSITY LABORATORY PRACTICES

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Abstract: It is known that for the development of a successful career of professional of any Science Degree it is essential to be able to handle and solve complex circumstances with the knowledge, skills and competences acquired during the years of university training. If we accept that learning is the result only of what students do and think, we come to the conclusion that it can only be achieved through many hours of laboratory practice. Among the different active methodologies and different from the classic lectures, PBL, problem-based learning, and TBL, team-based learning, have been used successfully in the first courses of the Biochemistry and Bioinformatics degrees. This has provided our students with a higher level of knowledge that has translated into a greater ability to solve problems, analyze data and, very importantly, think critically. This paper will present and discuss, with the participation of the students themselves, the application of these methodologies, which are causing an intense transformation in university education.
Keywords: Experiments, chemistry, first university course, active methodologies, PBL and TBL.

INTRODUCTION

The lack of interest in science careers in our country and in Europe (Fensham, 2004 and Martínez, 1998), together with a certain negative attitude towards science in our young high school students, conditions the moment of choosing a career.

They dismiss some of them because of their content in mathematics, physics or chemistry.

Currently, schools that teach science under the STEM (Science-Technology-Engineering--Engineering-Mathematics) model (Sanders, 2009) are trying to reverse this negative attitude. This approach requires the use of innovative and alternative teaching and learning methods, such as projects, laboratory practices and technological tools. Teaching becomes eminently practical and moves away from theoretical and repetitive learning. It focuses on the ability to innovate, invent and solve problems creatively.

A study published in 2014 (Freeman et al, 2014) conducted on 225 students in the United States of America, who were analyzed under the perspective of the STEM model revealed that such learning drastically reduces the percentage of college failure and has led students to obtain a higher level of knowledge and a greater ability to solve problems, analyze data or think critically. It shows that students do not gain a positive understanding of a tern, physics or chemistry or mathematics or? science, just by attending to theoretical explanations in a detached way.

Science education is based on inquiry (Jiménez Pérez, 2016 and Camacho, 2008). In it, students, working in groups and collaborating with each other, participate in the planning of an investigation to answer questions and/or real-life problems. To do so, they must gather information and data from sources within their reach. Then, they must propose explanations adjusted to their results to communicate them to the other groups in the class. They must express themselves using appropriate scientific terms, both in writing and orally. And finally, they must participate in public discussions in defense of their work and direct their explanations towards popularizing science.

Implementing this type of changes in the first university courses has an advantage, the results are often evident. The active methodologies most commonly used in the field of science are: CBL, from its , *case based learning* or learning based on the study of real cases, PBL (Schwartz, 2002), from its acronym, *problem based learning* or learning based on problems, TBL (de Vries, 2018), from its acronym, *team based learning* or learning based on teams and IBL, from its acronym, *inquiry based learning* or learning based on challenges.

Of these, PBL and TBL have been used as an educational innovation. The PBL and TBL models are developed jointly in the same groups of students and at the same time, to achieve greater motivation and participation by the first year students of the Biochemistry Degree of the University of Barcelona (UB) in the subjects of Chemistry I and Chemistry II and also in the degree of Bioinformatics of the Universitat Pompeu Fabra (UPF) in the subject "Aspects of Physical and Organic

Chemistry", both taught by the author since 2011 in the biochemistry degree and since 2016 the bioinformatics degree, the year of its implementation.

For our undergraduates, learning is the result of what the student does and thinks and this, in scientific studies, can only be achieved through many hours of well thought out and matured "practices". Our educational approach, problem-based learning, not only covers numerical problems in general, but we apply it to the resolution of problems and/or practical cases in the biochemistry and bioinformatics laboratory (PBL) and, always, it is done by a group, a team, of students (TBL) breaking the boundaries between the different models of active methodology.

This article presents and discusses the implementation of the PBL and TBL methodologies in both science degrees as a clear commitment to make students the protagonists. Finally, the conclusions/inputs from the students themselves about this educational innovation are presented.

CHARACTERISTICS OF THE STUDENTS OF THE BIOCHEMISTRY AND BIOINFORMATICS DEGREES

The different scientific degrees lead students to related but different professions, and this is reflected in the curriculum of each degree. Thus, while Biochemistry studies emphasize the experimental part with a significant number of laboratory credits, Bioinformatics studies emphasize computer practices.

GRADEBIOCHEMISTRY

It provides an understanding and use of the standard techniques of biochemistry and its basic quantitative aspects. The content of the "Chemistry I and II" program brings together a set of basic and essential concepts to subsequently develop a good part of the subjects that constitute the Biochemistry degree. 1. Basis of chemical reactions. 2. Atomic structure, chemical bonding and molecular structure. 3. Reactions in aqueous solution. Chemical equilibrium: acid-base, oxidation-reduction and precipitation equilibrium. 5. 5. Biomolecules (QI).

Students develop the ability to understand and explain the chemical principles of biochemical reactions and the experimental techniques used in this study.

BIOINFORMATICS DEGREE

It provides intra- and interdisciplinary training in both computational and scientific topics with a solid basic background in chemistry. The program content of *Aspects of Physical and Organic Chemistry* (APOC) Aspects *of Physical* and Organic *Chemistry* covers fundamental concepts in physical and organic chemistry and is distributed in:

1. Atomic structure and chemical bonding. 2. Chemical thermodynamics. Organic chemistry reactions. 4. Chemical equilibrium: acid-base equilibrium, oxidation-reduction equilibrium and precipitation equilibrium (APOC).

Students integrate, process, manage and interpret basic chemical data for a better understanding of biological phenomena.

SIMILAR COMPETENCIES IN BOTH DEGREES

Only a few will be mentioned to give the reader an idea:

- Elaboration and defense of arguments and problem solving within their field of study.
- Transmission of information, ideas, problems and solutions to specialized and non-specialized audiences.
- Acquisition of chemical knowledge at the micro and macro levels, with a special emphasis on biochemistry and organic chemistry applications.
- Training in frontier technologies and in the use of research tools and resources.

If we focus on the acquisition of competencies in the framework of a scientific degree, these can only be achieved by experimenting, reconstructing previous solutions and preparing to face new challenges in real contexts.

METHODOLOGY

With all these data and given the importance that laboratory work, chemistry in case, will have in the future of these professionals, it was decided:

Choose a set of relevant problems and/or questions with significant student interest. In the table below is a short list of such problems that the teacher discusses with students to choose or present an alternative.

These questions must be related, in general, to Biochemistry and Bioinformatics and, in addition, they must have a possible solution within the framework of "bio" research and work in the chemistry laboratory. Sometimes it is difficult to come up with ideas for experiments that help to solve them.

The different experimental approaches will be carried out by groups of 3 to 5 students in the class (Dennick, 1998). These groups should be formed spontaneously among the students without the need for any teacher participation.

Work done in the last 2 years with the questions they are trying to answer	
Iron in breakfast cereals How to measure iron in cereals and how can it be used?	**Osmosis, diffusion and dialy**sis. Can reverse be done and explained in the laboratory?
Carcinogenic substances Chemical safety of these substances and their three--dimensional representation.	**Acetylsalicylic acid synthesis** Study of the reaction between salicylic acid and acetic anhydride.
Respiratory alkalosis How to measure lung capacity? Differences between smoker/non-smoker.	**Blood pH regulation** Regulation of acid-base balance. Preparation of buffer solutions.
Self-heating / cooling foods Elaboration of devices of this type	**Radioactive isotopes in medicine** Why does its use make it possible to visualize an organ in different conditions?
Food antioxidants What is the concentration of polyphenols in different tea beverages?	**Milk with and without lactose** Does lactose-free milk have lactase and how is its activity measured?

The groups decide which question or problem to solve and spend 8-10 hours working on it. They design experiments with all the laboratory material at their disposal and under the supervision of the teacher.

The results obtained, together with the experimental script, are part of a final written report of a maximum of 10 pages following the guidelines of a scientific article: Abstract, Introduction, Methodology, Results, Discussion, Conclusions and References.

The teacher makes a thorough review of the results obtained together with the members of each group. After approval, each group can make an oral and public presentation, in front of the whole class, with computer support, where the results obtained are discussed and evaluated. In these presentations, each group must answer the questions and suggestions made by their classmates.

With all this in mind, the teacher will evaluate the activity, all presentations are evaluated by the teacher as an exercise of the course. The personal presentation, the support material, the final report and the response to questions from classmates will be evaluated. It is important that students understand and share the results of this evaluation in order to assess their own work.

The final grade of this activity, which can be different for each member of the group, has a value of 10-20% of the final evaluation of the corresponding subject, "Chemistry" in the Biochemistry Degree and "APOC" in the Bioinformatics Degree.

In order to assess whether problem-based learning is an activity that the students answered a questionnaire where, in addition to personal questions and questions about the grade in question, it is worth mentioning about this activity:

- What difficulties have you encountered during the realization of your work?
- How do you evaluate your participation in the experimental work, in the preparation of the ppt presentation and in the preparation of the final written summary?
- How do you evaluate your group mates and your relationship with the group?
- How can the relationship within the group be improved?
- What positive and negative points of your teamwork would you highlight?
- What would you change about your intervention in a future ?
- How do you value this activity?

RESULTS

The result of using the PBL and TBL models at the same time in university teaching turns chemistry learning into a more participatory process, where students can explore together new experimental approaches. Figure 1 and 2 show different moments of this educational activity.

Fig.1. Four presentations are shown: iron in cereals, thermodynamics of self-heating and self-cooling foods, radioactive isotopes and reverse osmosis.

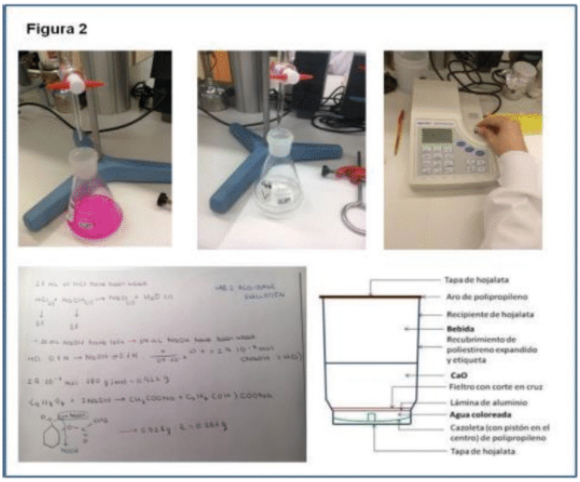

Fig.2. Different moments in the laboratory are shown: buffer titrations, measurement of polyphenols by spectrophotometry, notes on aspirin synthesis from one group of students and a self-heating device from another group of students.

The reader will understand that it is not necessary, at this point, to compare the academic results of these students with others who have not carried out this activity, because for this purpose, at the beginning of the course, the class should be divided into two groups, one with the formal classes and the other with the proposed activity. The author believes that if we refer to the courses on chemistry given by him, to the same type of students, in courses prior to 2011-2012, the difference in attitude and achievement is notorious.

At the end of the course, students were asked to answer questions aimed at evaluating this educational initiative. Their answers included the following:

Some groups have had difficulty finding the necessary information to broaden their knowledge on the topic to be developed. Others have had problems distributing the work and some members have worked much less than the rest. Also, the fact of making some presentations in English represents a certain difficulty.

On the personal and group evaluation regarding preparation and presentation, they are more demanding when evaluating themselves and the participation of each group member, but in no case has the variation exceeded 20% of the teacher's score.

In order to improve the work, it is necessary to analyze the negative points, basically, poor communication among the members of the group, which has repercussions on the incorrect distribution of the work. They also indicated that, for future work, they would try to organize themselves better and, above all, they would dedicate more time to preparing and making the presentation.

Finally, 245 participants of the Biochemistry degree and 62 of the Bioinformatics degree, have scored this educational innovation between 1-5, being 1 (negative valuation) and 5 (very positive valuation). The results of the biochemistry degree were 4.5±0.4 while those of the bioinformatics students were 4.3±0.6.

CONCLUSIONS

- The students of the bioinformatics degree presented, initially, a certain reluctance to laboratory work that, later on, became enthusiastic. On the other hand, the biochemistry students have always been predisposed to laboratory work.
- This educational activity provides the opportunity to learn through practical projects designed to respond to the scientific concerns of students in a real scenario. increases students' motivation and interest in science.
- The great acceptance of this methodology among students encourages faculty to continue in this direction. The application of such methodologies (Deslauriers, 2011) is causing an intense transformation in university education.

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