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Teaching proposal for the subject of unit operations at the university level through project-based learning (PBL) methodology

Propuesta de enseñanza para la materia de operaciones unitarias a nivel Universitario mediante la metodología de aprendizaje basado en proyectos

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Abstract

Several studies have proposed Project-Based Learning (PBL) as one of the most effective methodologies to achieve competency-based education. The objective of this work was to test the PBL methodology in a group of university to meet competencies. This test was applied to 25 students group divided into teams that were tasked with developing a prototype for a different part of a unit operation. The final product was the demonstration of the operation of the prototypes individually and together. In the first part, students were asked to make a design proposal. Once the design was accepted, the construction of the equipment with commonly used materials was prepared. Subsequently, the performance and characteristics of the assembled prototypes were presented to an evaluation committee. Based on the results obtained, it can be concluded that the PBL methodology proposed in this work contributed to the development of competence by students. We believe that the use of the PBL methodology could enrich the learning of Engineering students, as well as bring it closer to real scenarios.

Project-Based Learning, Unit Operations, bioreactor

Resumen

Varios estudios han propuesto al Aprendizaje Basado en Proyectos (ABP), como una de las más efectivas metodologías para lograr una educación basada en competencias. El objetivo del presente trabajo fue probar la metodología de ABP en un grupo de educación superior para cumplir competencias. Esta prueba fue aplicada en un grupo de 25 estudiantes divididos en equipos a los cuales se les encomendó desarrollar un prototipo para una parte diferente de una operación unitaria. El entregable final fue la demostración de la operatividad de los prototipos de manera individual y en conjunto. En la primera parte se le solicito a los estudiantes que hicieran una propuesta de diseño. Una vez aceptado el diseño se dispuso a la construcción de los equipos con materiales de uso común. Posteriormente se hizo la presentación del funcionamiento y características de los prototipos ensamblados frente a un comité evaluador. A partir de los resultados obtenidos, se puede concluir que la metodología de ABP propuesta en este trabajo contribuyo a que los estudiantes pudieran desarrollar la competencia. Consideramos que el empleo de la metodología ABP, podría enriquecer el aprendizaje de los estudiantes de Ingeniería, así como acercarlo a escenarios reales

Aprendizaje Basado en Proyectos, Operaciones Unitarias, Biorreactor

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1. Introduction

It is well known that nowadays some of the qualities that a good engineer must have are: the ability and willingness to learn, extensive knowledge of basic sciences and training in the use of software related to the area, but mainly must be prepared to learn permanently, as well as to communicate assertively and the ability to work in a team, so their education should be more comprehensive. Taking into account the above, several studies have proposed Project Based Learning (PBL) as one of the most effective methodologies to achieve a competency-based education because it can integrate knowledge, skills and values (De los Ríos, et. al., 2015 and Ausin, et. al., 2016).

This innovative methodology bets on a more active role of the student within the classroom and on a modification of the teacher's role (Rodríguez-Sandoval and et. al., 2010). PBL is a methodology that implies a change in the pedagogical paradigm, since it promotes the simulation of a real classroom environment, as well as the integration of acquired knowledge, critical thinking and collaborative work. This methodology is based on students formulating a work plan defined by objectives, which must be periodically fed back, in addition to the presentation of a final product that will be evaluated through a series of standardized evaluation criteria.

Therefore, the university teacher must possess a series of knowledge, skills and aptitudes that allow the generation of significant knowledge through the approach of situations that simulate real life (Martinez Valdes, 2021). According to the curriculum design methodology of the Technological and Polytechnic Universities, competencies are disaggregated into two levels of performance; units by competence and capabilities, we contribute to the achievement of improving the competence of coordinating processes and bioprocesses based on the use of chemical and biological inputs, modeling techniques, scaling and instrumental analysis, to develop methods of control and personnel development, for quality management optimizing human, technological and natural resources that contribute to the transfer of knowledge and productive sectors with a focus on national and international competitiveness (Callejas Torres, et. al., 2017, de la Garza Vizcaya, 2013 and UPCI, 2018).

Thus, the objective of the present work was to test the PBL methodology in a higher education group of Biotechnology Engineering for the subject of Unit Operations to meet the previously described competence.

Methodology to be developed

In the municipality of Cuautitlán Izcalli, State of Mexico, the Polytechnic University of Cuautitlán Izcalli (UPCI) is located (Figure 1), where the Biotechnology Engineering program is taught and which includes Unit Operations as part of its 6th quarter curriculum.

Figure 1 Location of Universidad Politécnica de Cuautitlán Izcalli (UPCI)
Source: Google maps

This test was applied to a group of 25 students between 19 and 23 years old, who were divided into teams of 4 or 5 members, each team was given the task of developing a team for a different part of a unitary operation (milling, maceration, cooling and fermentation), so that the final deliverable was the demonstration of the operation of the prototypes individually and as a whole.

Monthly reviews were made of the progress of each of the teams, which were evaluated by means of checklists.

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Design proposal

For this first part the students were asked to make a proposal, through a bibliographic research and specialized software (Lab VIEW, for the design and COCO simulator, for the calculations), about the design of each one of the equipments taking into account that these could be used individually or together with the other equipments assigned in the group, The main objective of this part was for the student to propose a design by analyzing its conditions, parameters, type, operation configuration, mass and energy balances, movement, heat transfer operations and its possible use and application. This part was evaluated by means of heteroevaluation by the teacher**.**

Assembly and assembly of the prototype

Once the design was accepted, the construction of each one of the equipments with commonly used materials was started. The objective of this part is that the students build their equipment considering their conditions, parameters, type and configuration of the operation. The evaluation of this part was carried out by means of heteroevaluation by the teacher.

Demonstration

Once the different prototypes were built, we proceeded to the demonstration of the operation of the equipment individually and as a whole, this was done by assembling and operating the equipment. For the evaluation of this section, a co-evaluation among the members of the same team and a self-evaluation were requested. Likewise, a hetero-evaluation of the presentation of the prototypes, characteristics, advantages and disadvantages was carried out by an evaluation committee made up of specialists in the process area.

Results

The results obtained from this pilot test are described below:

Design proposal

In this first review, the students presented the designs of the prototypes of the different devices: mill, macerator, cooler and fermenter. Once they were reviewed, the pertinent observations were made and returned to the students so that they could be taken into account.

Prototype assembly and assembly

Once the students attended to the corresponding observations, we proceeded to the construction of the prototypes, in figure 2 you can see the ball mill prototype.

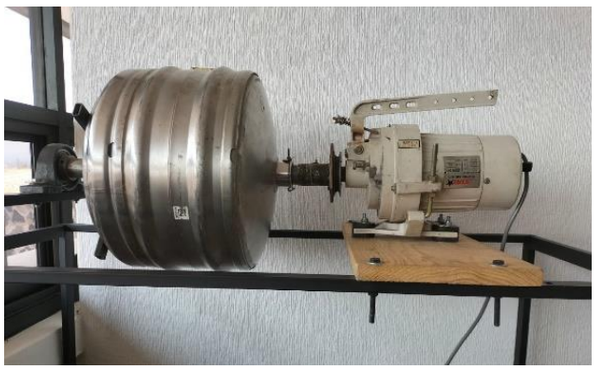

Figure 2 Prototype of a ball mill

Figure 3 shows the macerator built with easily accessible material, this macerator has a temperature control that is visualized through a display located on the outside of the prototype.

Figure 3 Macerator with temperature control, showing the display on the outside of the prototype

Figure 4 shows the cooler built from simple materials and with a copper coil inside the prototype.

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Figure 4 Cooler prototype. A: external view of the cooler. B: view of the copper coil inside the cooler

Finally, in Figure 5 we can see the fermenter, also built from simple and easily accessible materials.

Figure 5 Fermenter prototype

Demonstration

Finally, Figure 6 shows the different devices assembled to work together. The performance and characteristics of the assembled prototypes were presented to the evaluation committee.

Figure 6 Unit operation system consisting of: 1: mill, 2: macerator, 3: cooler, and 4: fermenter

Co-evaluation and hetero-evaluation were carried out by means of a Google form for the 25 students who took part in the pilot test.

Conclusions

From the results obtained, it can be concluded that the PBA methodology proposed in this work contributed to the students of Unit Operations of Biotechnology Engineering to cover the competence of coordinating processes and bioprocesses based on the use of chemical and biological inputs, modeling techniques, scaling and instrumental analysis, to develop methods of control and personnel development, for quality management optimizing human, technological and natural resources that contribute to the transfer of knowledge and productive sectors with a focus on national and international competitiveness, in a satisfactory manner.

Some of the areas of opportunity that could be observed throughout the implementation of this pilot test were: to have a greater specificity in the requirements that are reflected in the checklists, the application of a relevant evaluation instrument to know the opinion of students about the implementation of this type of methodologies and the impact on their learning and seek to optimize the time in the application of each of the stages to add the part of production at the test level.

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We consider that the use of the PBL methodology could enrich the learning of engineering students, as well as bring them closer to real scenarios that they will face during their professional career.

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