09-010

TEACHER- STUDENT EXPERIENCE: WORK IN A PILOT PLANT OF REVERSE OSMOSIS.

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Some Higher Education systems incorporate innovation in their training structure, prioritizing project based learning (PBL), reverse teaching or the Learning by Doing method. Knowing the good results of these methodologies, the Universidad Católica Boliviana San Pablo ventures into the application of the Learning by Doing methodology. This article exposes the work in a reverse osmosis pilot plant, where young undergraduate researchers from the Environmental Engineering Career are involved, seeking to complement their academic training. The development of the practices will be presented, as well as the evaluation of the experience of the teacher and the students who participated in the project.

Keywords: Learning;by;doing;reverse;osmosis

EXPERIENCIA DOCENTE - ESTUDIANTIL: TRABAJO EN UNA PLANTA PILOTO DE ÓSMOSIS INVERSA.

Algunos sistemas de Educación Superior incorporan la innovación en su estructura formativa, priorizando el aprendizaje basado en proyectos (ABP), la docencia inversa o el método Aprender-Haciendo. Conociendo los buenos resultados de estas metodologías, la Universidad Católica Boliviana San Pablo incursiona en la aplicación de la metodología Aprender-Haciendo. Este artículo expone el trabajo en una planta piloto de ósmosis inversa, donde se involucra a jóvenes investigadores pre grado de la Carrera de Ingeniería Ambiental, buscando complementar su formación académica. Se presentará el desarrollo de las prácticas, como también la evaluación de la experiencia del docente y de las estudiantes que participaron en el proyecto.

Palabras claves: Aprender; haciendo; ósmosis; inversa

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1. Introduction

The European Higher Education Area (EHEA) introduces the change in conventional teaching processes towards active methodologies, through innovative strategies to evaluate the effort of students together with the knowledge acquired. With the aim of linking teachers and students during the training process (UMA, 2021). The teaching model is at a key moment of transition for change, the new academic organization must consider modalities beyond the simple theory and practice dichotomy and incorporate active methodologies (De Miguel, 2006).

We learn by interrelating action, theory and experience. What has been learned is consolidated, expanded and generalized through theory, which corresponds to accumulated knowledge that is not very efficient without action. Therefore, an active methodology is the process by which you learn by doing (Gamboa & Garcia, 2012). Among the active methodologies we can mention the methodology of Learning by Doing. This practice supposes the stake of knowledge in action, reflection in the action and by default it requires a reflection on the action. The Learning by Doing methodology is useful as a training for real professional practice, based on principles of analysis, reflection, planning and evaluation (Schön, 1992, Vargas & Rodriguez, 2012). With this methodology, group and individual works are promoted in which students have opportunities to generate their own knowledge and apply it (Águeda & Cruz, 2005, Rodriguez & Ramirez, 2014).

Within the Learning by Doing methodologies there is a subtype that is also gaining strength in its application, it is called Project Based Learning (PBL). When carrying out this methodology, a project is assigned, within which students must participate in both the theoretical and practical parts (Moreno, Pavon & Rincón, 2017). This teaching methodology focuses on students as protagonists of their own research-based learning (Bradley-Levine & Mosier 2014).

One of the main problems in Latin American higher education is that its focus is on the formation of theoretical skills and active methodologies are neglected (Aboites, 2010). There is a conventional structure in the study plans focused on passive teaching methods, which implies little attention to the practical part and with evaluation procedures aimed at measuring theoretical competences (Fernandez & Perez, 2016). In Bolivia, higher education has the need to reform conventional teaching-learning methodologies in order to address the challenges derived from innovation that active methodologies entail.

This work presents the results of the teaching-student experience based on the Learning by Doing methodology, through work in a Reverse Osmosis pilot plant. This study was carried out with students in the last semesters of the Environmental Engineering career at the Bolivian Catholic University in La Paz - Bolivia.

2. Goal

Apply the Learning by Doing methodology, seeking that young undergraduate researchers from the Environmental Engineering Career at the Bolivian Catholic University "San Pablo" complement their academic training, and thus be able to cross the barrier from the theoretical to the practical.

3. Methodology

In the nineteenth century, pragmatism establishes that "theories, experiences and any learning have value, if they are applicable to real life and ultimately, if they are practical" (Putnam, 1992). The methodology of Learning by Doing that will be implemented is based on learning against the approaches based on traditional teaching (Rodriguez & Ramirez, 2014). Therefore, this pedagogical methodology moves away from the didactic techniques based on memorization and approaches the techniques of knowing through experiences (Moerbeke, 1982, Wompner, 2007). Studies have denoted that 21st century learning is linked to teaching through experiences, this to improve critical thinking in professional education (Pamungkas, Widiastuti, & Suharno, 2020). Learning by Doing is the educational experience where more than knowledge, skills, abilities, attitudes and habits of thought and action are generated with the purpose of expanding the frontiers of knowledge and know-how (Herrera, 2005). Universities such as the Massachusetts Institute of Technology, North Carolina State University, and Aalborg University are implementing active learning methodologies. In the specific area of engineering education, Tecnológico de Monterrey had interesting results, such as: development of teamwork skills, creativity in problem solving, and increased analytical skills (Hernandez-de-Menéndez. Et al., 2019). The teacher-student experience presented in this study, oriented to work in a reverse osmosis pilot plant, was developed to achieve specific personal skills, which were abstracted from previous studies. These skills are observed in Table 1.

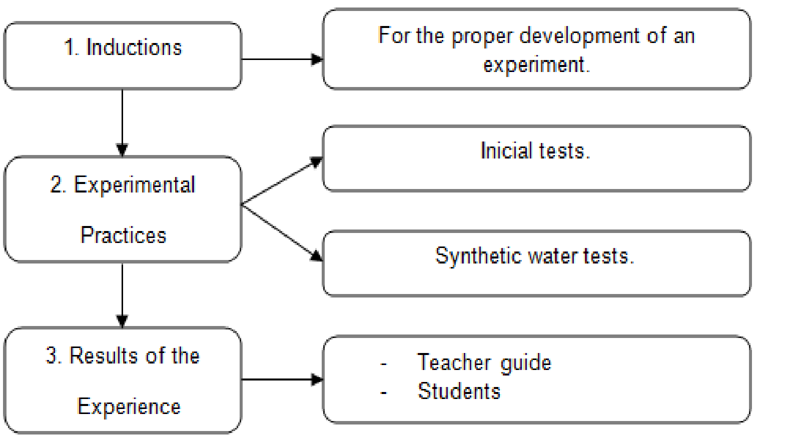
Table 1. Specific Skills

Specific skills	Skill detail	Academic Study of Teaching - Learning
Study in a self-taught way	People learn by themself and are active during the construction of knowledge.	Shuell, 1986; Stern & Huber, 1997
Self-regulation	Create and perceive your own activities, evaluate the results of the activities and re-evaluate new activities yourself.	Kanfer, 1977
Construction of knowledge based on experience	Individual knowledge starts from a personal construction that is interpreted through perceptions or experiences, depending on their available knowledge or opinions.	Schön, 1991
Applicability of theoretical knowledge	The learning context offers or reflects real opportunities to experience and apply the knowledge acquired.	Jonassen, Mayes & McAleese, 1993
Group work ability	Learning is not an exclusively individual process, but a sociocultural interaction, since each one converts his internalized knowledge into a sequence of ideas to communicate them and vice versa, when he listens to ideas, opinions, and suggestions from others. The advantages of dealing with tasks and problems are experienced in teams willing to join forces to solve their tasks.	Wertsch, 1985; Vygotskij, 2002; Lave & Wenger, 1991.

Source: Own elaboration, 2021.

This study was structured in 3 phases, which are observed in Figure 1. In the first phase, inductions are developed for adequate experimental work. The second phase involves experimental work in a reverse osmosis pilot plant. Finally, in phase three, the results obtained are evaluated through surveys of students.

Figure 1. Methodological diagram



Source: Own elaboration, 2021.

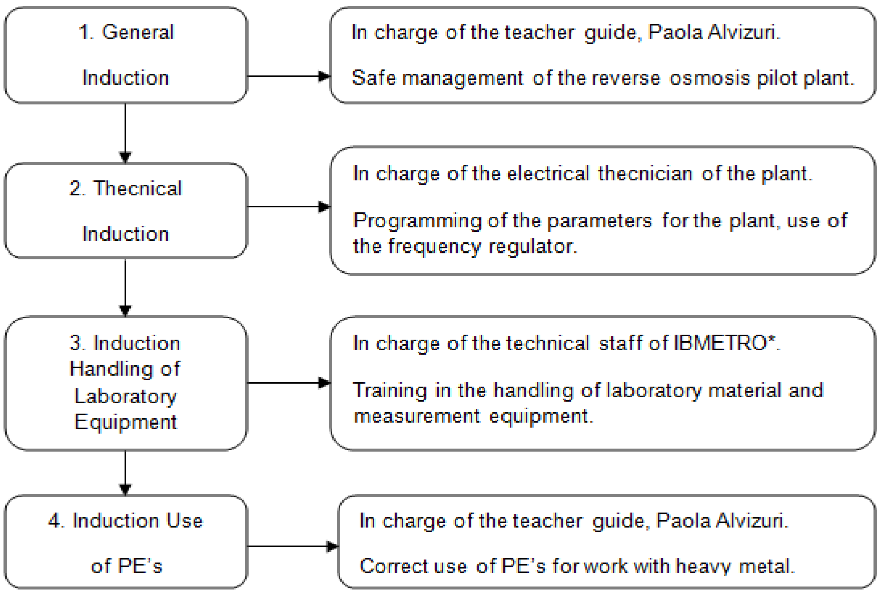
4. Case study

The Bolivian Catholic University is always aligned with the process of continuous improvement, so it seeks to optimize its teaching-learning processes. The case study presented was proposed to translate the theoretical knowledge acquired by the students into practice. This complements the training of students with the acquisition of skills applicable to their professional performance. The steps that were followed in the experience of working with students in a pilot plant for reverse osmosis are detailed below.

4.1. Induction for laboratory work and pilot plant management

To start with the experimental practices, different inductions were carried out, which are detailed in Figure 2. The inductions were carried out in a participatory workshop format by the project's teacher guide and personnel specialized in handling equipment.

Figure 2. Induction's diagram

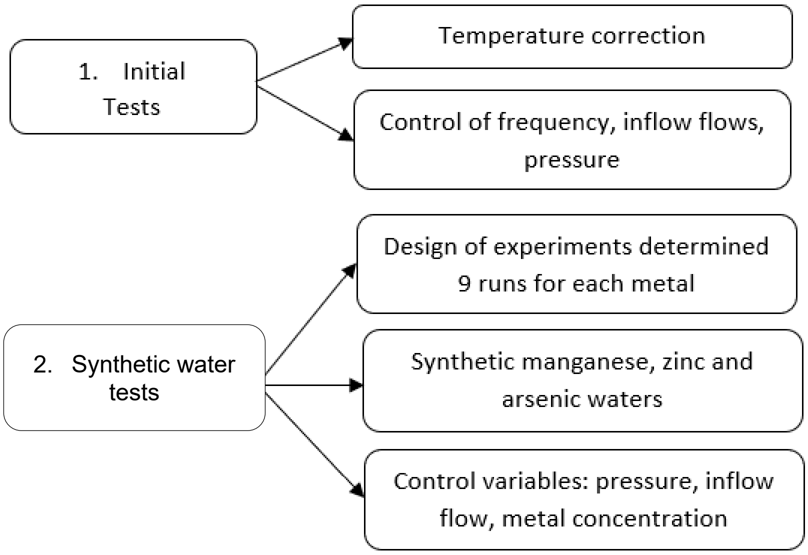


Source: Own elaboration, 2021.

4.2. Experimental practices

Figure 3 shows a diagram of the tests performed. The explanation of the objective of each of the tests is described in the following sections

Figure 3. Process diagram



Source: Own elaboration, 2021.

4.2.1. Initial tests

These tests were carried out to learn to control the different variables of the plant such as frequency, inflow flows and pressure. In addition, a temperature correction was made to standardize this variable and not have the need to work at a fixed temperature in the subsequent tests.

4.2.2. Synthetic water tests

These tests were carried out with synthetic manganese, zinc and arsenic waters. Nine runs were made for each metal. The number of runs was determined by means of a previously carried out design of experiments. For this, three control variables were taken (pressure, intake flow and metal concentration) and a response variable (percentage of removal of the metal ion).

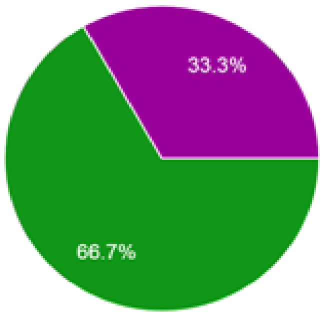
5. Results of the experience

The results of the experience will be presented below. In the first place, the student's perception of the performance of the leading teacher in the experience will be analyzed. Then, the competencies that students believe they have achieved through experience will be exposed.

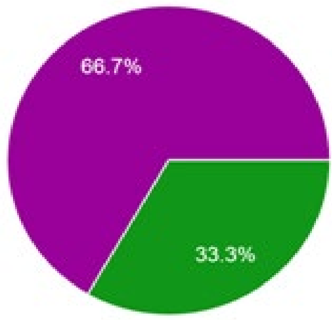
5.1. Results of the survey given to the students

The results of the survey that the students filled out anonymously to evaluate the guidance of the teacher in charge of the experience are presented below. The teaching evaluation instrument used is the official one from the Bolivian Catholic University "San Pablo". The survey is presented in the annex to this article.

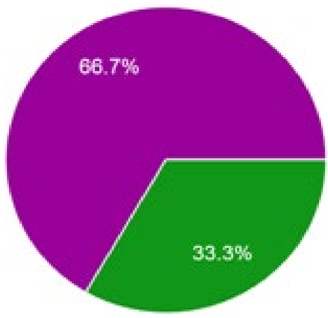
Figure 4. Results of the survey



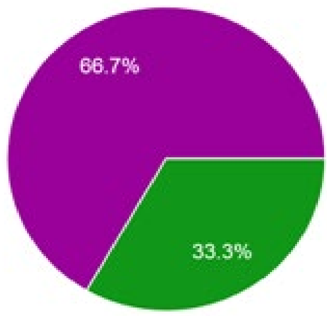
Question 1: Planning and organization of activities.



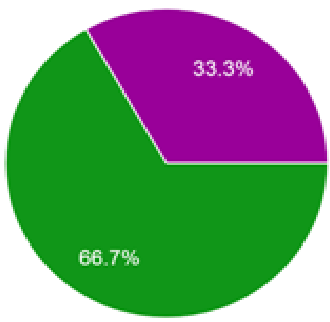
Question 2: Application of conceptual knowledge in the project.



Question 3: Implementation of new teaching strategies.



Question 4: Use of suitable didactic spaces for the development of the project.



Question 5: Coherent teaching and assessment system.

Question 6: Generation of an inclusive and participatory climate.

Source**:** Own elaboration, 2021.

Note: From questions 1 to 5 it is observed that the answers were very satisfactory, they were between "Very good" and "Excellent". It should be noted that the answer to question 6 shows that 100% consider that the climate generated during the project was excellent.

Observing the previous answers, it can be said that the appreciation of the students regarding the performance of the teacher guide in the experience was very good or even excellent. Also, the students were asked what specific personal skills they think they achieved through experience. The responses are shown in Table 2.

Table 2. Specific skills developed

Specific Skills	Study in a self-taught way	Self-regulation	Construction of knowledge based on experience	Applicability of theoretical knowledge	Group work ability
Student 1	X	X	X	X	X
Student 2		X	X	X	X
Student 3	X	X	X	X	X

Source: Own elaboration, 2021.

The favorable responses to the performance of the teacher guide and the different skills that the students consider to have achieved show us that the experience was developed successfully.

6 Discussion

Previous studies denote that developing countries such as Bolivia require specialized training to meet the needs of the different emerging technological areas of the region (Lo Iacono, et al. 2018). In this sense, the implementation of technology management from undergraduate training is important. This type of experience linked to students, manages to reduce the gap between theory and practice. In addition to complementing the training of future engineers with useful practical skills for their future employment.

The implementation of active methodologies within a conventional teaching-learning format is always a challenge. But when you work with committed people, the result is always favorable. Students want to learn and it is the duty of the teacher to have the best strategies so that their training is complete and comprehensive.

Considering that many times the resources and equipment for experimentation and even space are limited in the University, forming a small group of 4 participants (3 students and 1 teaching guide) had favorable results. A greater number of students would have generated difficulties due to the economical limitation of having a single pilot plant, causing that not all the students could develop the full activities of the experience. In addition, due to the health emergency of Covid 19, restrictions for laboratory work arose, delimiting 4 people as the maximum capacity. Must stand out that working with a small group prioritizes personalized teaching in the experience, which enriches the training of students.

This experience gained attention and was published in the news of the Bolivian Catholic University "San Pablo". Demonstrating an innovation and an example to be followed by other academic departments.

Figure 5. "Learning by Doing" Experience in Environmental Engineering

Source: Bolivian Catholic University "San Pablo", 2021.

Figure 5 shows the location where the tests were performed. This laboratory belongs to the Water, Energy and Sustainability Research Center (CINAES) of the Environmental Engineering Degree. The reverse osmosis plant was assembled within the doctoral project of the teacher guide Paola Alvizuri PhDc.

6. Conclusions

The article presents the teacher-student experience at work in a reverse osmosis pilot plant. which complements the undergraduate training of the students involved. An active teaching-learning methodology was applied, "Learning by Doing". This methodology treats that the knowledge that a professional must acquire is achieved by interrelating theory, action, and experience.

Currently, higher education has had to accommodate to virtuality, due to the health emergency of COVID 19, this has caused that many practical skills are not fully achieved. Therefore, to adjust to the new normal, the implementation of short active experiences is the perfect complement that would reinforce the theoretical knowledge acquired in distance classes.

From the experience we can highlight the great interaction and co-responsibility achieved by the students and the teacher who participated in this project. With the results of the survey of the student body, we can conclude that the application of the Learning by Doing methodology, new for the students, was carried out in a successful manner. The responses regarding the assessment of the guide teacher and the competencies achieved are positive, so the three participants were satisfied with the experience. Applying an active methodology, the training of the students is completed and above all it becomes more practical.

This experience showed that it is possible and favorable to change the conventional learning teaching methodology. If it is done in an organized and correct way, the barrier that exists between theory and practice is crossed. This enhances the learning experience for everyone involved. Finally, It is necessary to continue with the implementation of active methodologies in all areas, exploring other experiences that can continue to develop and strengthen the professional skills of students. For this to happen, the infrastructure and equipment limitations of the universities must be overcome.

If there are no space and equipment limitations, future studies should look to work with larger groups to see if the results remain positive. It should also be considered that the Learning by Doing methodology requires rigorous supervision and monitoring of the teacher guide, which is somewhat difficult in very large groups. This active methodology is also highly personalized, which could be a limitation in large groups.

7. Glossary

- **CINAES:** Water, Energy and Sustainability Research Center
- **IBMETRO:** Bolivian Institute of Meteorology.
- **PE's:** Protection equipment.
- **PBL:** Project Based Learning (PBL

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Communication aligned with the Sustainable Development Goals

Annexes

Survey for the project participants

No.	Items	Performance grade				
		Bad	Regular	Good	Very good	Excellent
1	Planning and organization of activities					
2	Application of conceptual knowledge in the project					
3	Implementation of new teaching strategies.					
4	Use of suitable didactic spaces for the development of the project.					
5	Coherent teaching and assessment system					
6	Generation of an inclusive and participatory climate.					