Problem-Based Learning with the Jar Test: Empowering Students to Solve Real-World Water-Treatment Challenges

UNIVERSIDAD DE MURCIA
GREEN CHEMICAL PROCESS ENGINEERING

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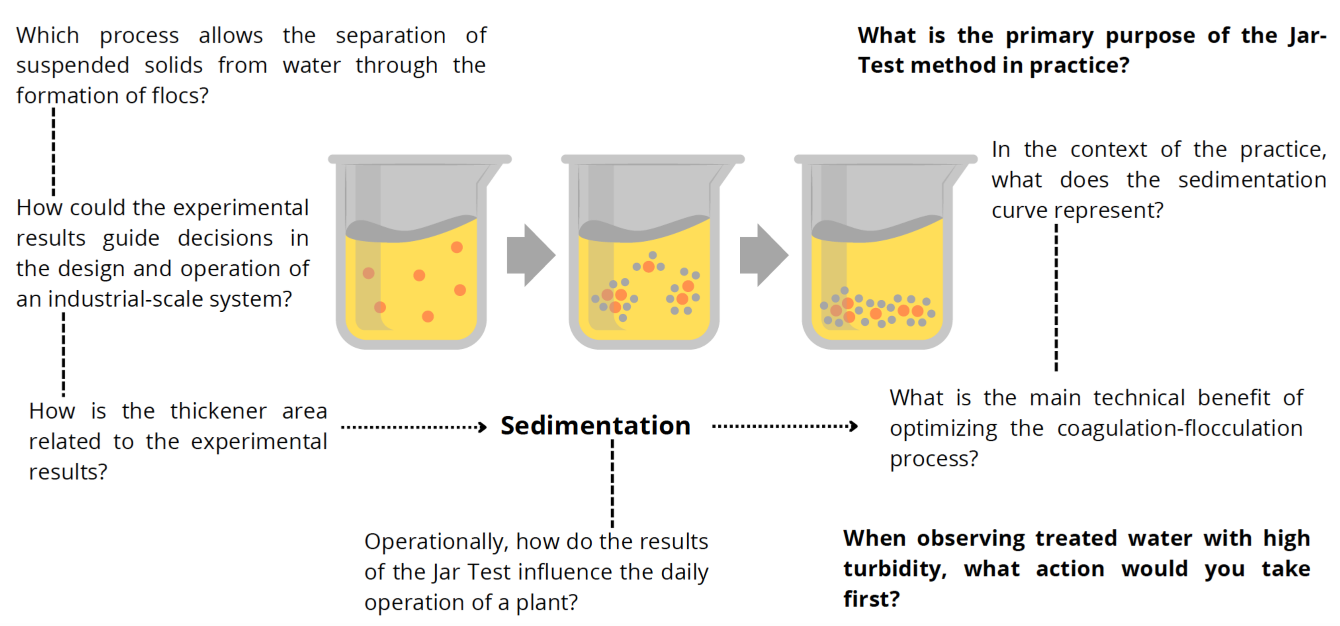
Chemical engineering is a demanding profession that now requires a broader set of interdisciplinary skills, especially in light of Industry 4.0. This evolution has led to Education 4.0, which emphasizes student-centered, competency-based learning supported by digital tools and active methodologies. Among these, Problem-Based Learning (PBL) stands out for using real-world problems to enhance critical thinking and problem-solving skills. PBL promotes collaboration, student autonomy, and guided learning, but it can be strengthened through Cooperative Learning (CL) [1].

The integration of both methods, known as Cooperative Problem-Based Learning (CPBL), is gaining popularity in engineering education. CPBL encourages small-group collaboration and mutual support, improving learning outcomes, interpersonal skills, and self-confidence [2]. It is especially effective in medium-sized classes, following a three-phase process: problem analysis, application and solution, and generalization. In practical subjects, CPBL bridges theory and real-world application. Laboratories offer hands-on experience, although their learning impact has sometimes been debated. Still, CPBL appears to be a promising tool to enhance the overall teaching and learning process in chemical engineering [3].

Therefore, this study proposes the use of a CPBL-based activity to reinforce the acquisition of competencies and skills in a practical session within the course Laboratory of Chemical Engineering V of the Chemical Engineering Degree at the University of Murcia. In particular, the activity is designed for the practical session focused on the Coagulation–Flocculation Test (Jar Test). Students' prior knowledge for conducting this practical session includes primary water-treatment operations such as primary sedimentation, flotation, and coagulation–flocculation processes. All students participated in the session, and among them, five groups (a total of 22 students) also completed the CPBL activity. After the practical sessions, all students completed a questionnaire to measure the potential improvement linked to the CPBL activity.



Question	CPBL (22)	NO CPBL (21)
Which process allows the separation of suspended solids from water through the formation of flocs?	100,0	95,2
What is the primary purpose of the Jar Test method in practice?	77,3	71,4
In the context of the practice, what does the sedimentation curve represent?	90,9	76,2
What is the main technical benefit of optimizing the coagulation-flocculation process?	72,7	52,4
When observing treated water with high turbidity, what action would you take first?	45,5	38,1
What information do you need to calculate the thickener area using the Talmadge-Fitch method?	81,8	85,7
Operationally, how do the results of the Jar Test influence the daily operation of a plant?	81,8	81,0
How is the thickener area related to the experimental results?	77,3	85,7
How could the experimental results guide decisions in the design and operation of an industrial-scale system?	100,0	95,2
Average	80,8	**75,7**

FIGURE 1. Simplified scheme of the coagulation–flocculation method. TABLE 1. Post-Lab Questionnaire Results with percentage of correct answers (highlight highest values in green).

The results show that these activities enhance the acquisition of skills and increase student interest.

Acknowledgement

Adrián Hernández Fernández has a grant (21817/FPI/22) from the Seneca Foundation. Eduardo Iniesta López has a grant (22345/FPI/23) from the Seneca Foundation. The authors also acknowledge the funding received from the University of Murcia through the Teaching Innovation Group in Chemical Technology.

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