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Use of virtual environments and project-based learning for teaching industrial costs: UFPS case study

Uso de entornos virtuales y aprendizaje basado en proyectos para la enseñanza de costos industriales: caso de estudio UFPS

PhD. Raquel Irene Laguado Ramírez[1]

[1] ***Universidad Francisco de Paula Santander,*** *Facultad de Ingeniería, Departamento de Procesos Industriales, Cúcuta, Norte de Santander Colombia.*

Correspondence: *raquelirenelr@ufps.edu.co*

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Abstract: This article evaluates industrial engineering students' perceptions of the teaching strategies used in the Industrial Costs course, comparing the Problem-Based Learning (PBL) methodology and case studies with other complementary strategies, highlighting strengths, weaknesses, and opportunities for improvement. The study employed a quantitative, descriptive, non-experimental cross-sectional design, using a 16-item Likert-type questionnaire with five rating levels. The sample consisted of 45 students who took the course during the second semester of 2023 and the first semester of 2024, applying PBL as a learning strategy. Data were collected online through Google Forms, and frequency, percentage, and measures of central tendency were analyzed. The instrument was structured into two dimensions: (1) PBL and case studies (10 items) and (2) complementary strategies (6 items). The results show high mean scores for PBL, identifying it as a motivating and high-performance strategy, and recommending it as the core approach of the course.

Keywords: PBL, teaching strategies, case studies, industrial costs, student perception.

Resumen: El presente artículo evalúa la percepción de estudiantes de ingeniería industrial sobre las estrategias pedagógicas empleadas en la asignatura de costos industriales, comparando la metodología ABP y estudios de caso con otras estrategias complementarias, reflejando fortalezas, debilidades y oportunidades de ajuste. La metodología fue cuantitativa, descriptiva, con diseño no experimental–transversal, mediante un cuestionario tipo Likert de 16 ítems y 5 niveles de valoración. La muestra estuvo conformada por 45 estudiantes que cursaron la asignatura en el II semestre de 2023 y I semestre de 2024 y utilizaron ABP. La información fue recopilada en línea por formulario Google Forms, realizándose análisis de frecuencia, porcentajes y medidas de tendencia central. Se construyó la prueba en dos dimensiones: (1) ABP/estudios de caso (10 ítems) y (2) Estrategias complementarias (6 ítems). Entre los resultados se evidencian medias altas en ABP, como estrategia motivadora y de alto rendimiento, recomendándose como eje articulador de la asignatura.

Palabras clave: ABP, estrategias pedagógicas, estudios de caso, costos industriales, percepción estudiantil.

1. INTRODUCTION

Education is an essential component for the progress of society and individual development. Likewise, curriculum projects are the framework that guides the educational process, and their efficiency and effectiveness are the critical factors that measure their success or failure, which directly influence the quality of education [1]. To strike a balance between efficiency and effectiveness, a balanced approach must be considered, where pedagogical practice is one of the qualities that precedes implementation, and where the objectives and goals to be achieved within any area of training must be clearly defined [2].

Under these premises, higher education is the fundamental pillar for the economic development of any country. In recent decades, the field of engineering has advanced in training practices, which have been characterized by a focus on optimization and effectiveness [2]. In this context, training in industrial costs in the industrial engineering degree program is highly relevant, constituting an essential component that is directly linked to accounting and logistics, enabling sound decision-making in productive environments [3]. Among the training objectives of this subject is the acquisition of specific skills such as identifying, measuring, accumulating, allocating, and controlling costs, which are necessary for resource planning, process evaluation, and decision-making within a project [4].

For this reason, in order to understand pedagogical practice in these times, one must first understand the adaptation processes that teachers face in their educational context and then conceive critical reflection as the foundation of learning. According to [5], the concept of critical reflection in pedagogical practice is viewed as a process of continuous evaluation of the strategies and methods that teachers use in their professional work. In this scenario, the teaching methods applied by teachers in industrial cost training present different challenges in their practice, since the diversity of concepts used in this area and the use of traditional pedagogies reveal a lack of connection with the reality of business, hindering a deep and meaningful understanding of the subject [6].

According to a review of the state of the art in terms of strategy management in the field of engineering, and specifically in the subject of industrial costs, significant shortcomings have been revealed; among the most notable is the limited use of the PBL methodology. Various studies reveal that, although students recognize PBL as a training strategy, its effective application in the classroom is scarce [7]. Likewise, in this research paper, the authors evidenced a marked use of traditional methodologies over innovative methodologies, which is a factor that detracts from the quality of engineers in training [7].

Another relevant factor that persists is the weak link between theory and practice in the teaching of industrial costing subjects. Research conducted between 2020 and 2024 documents the difficulty students have in connecting theoretical cost accounting content with real-world situations [8]. This gap is compounded by the lack of teaching practices that use interactive tools, resulting in superficial learning that leads to recurring errors in cost classification and allocation, poorly documented decisions, difficulties in data integration, and little or no experience in using simulators. These shortcomings accentuate decision-making insecurity in the future engineer's workplace [8].

Given this situation, it is necessary to evaluate the teaching practices used by teachers in the subject of industrial costs and then carry out a restructuring that allows for the introduction of innovative teaching approaches in this area. The implementation of active learning strategies will enable students to develop critical thinking and problem-solving skills, focused on theory, which can be applied in real-life contexts [9].

According to experiences based on different studies, the PBL methodology has proven to be highly effective for learning processes in the field of engineering, as it provides pedagogical tools that enable motivating interaction between teachers and students [10]. These approaches stimulate autonomy and critical thinking and promote the holistic integration of knowledge in demanding learning contexts [11].

In this context, the Francisco de Paula Santander University (UFPS) and the Department of Industrial Processes recognize the need to diversify pedagogical practice, given that teaching industrial costs requires strategies that link theory with technical knowledge in real contexts, where the decisions made by engineers are in line with the needs of these scenarios [12]. According to [13], comprehensive learning about costs in industrial operations involves developing analytical skills during the training stage. Therefore, teaching practices should focus on improving conceptual assimilation and enhancing the practical applicability of this knowledge by students.

1.1 Training engineers: a strategic pillar in industrial cost teaching

According to [14], training engineers must have a direct relationship between theory and practice, which can be said to be a key aspect of education, as these dimensions are complementary in guiding educational practice. In this case, incorporating knowledge of industrial costs, theory provides the conceptual framework for practice to be applied and validated in different industrial contexts. This interrelationship is fundamental to promoting inclusion and transformation in engineering pedagogy.

In this scenario, critical reflection focuses on the self-awareness that teachers must possess in order to identify their strengths and weaknesses, shaping their strategies according to flexibility and adaptation that must be implemented in accordance with the context of the students [15], [16]. It is important for teachers to bear in mind that critical reflection promotes consistent learning, where strategies are not only implemented, but their content and the ethical and social considerations of their practice are also analyzed.

According to [17], the training processes taught in the field of engineering must have a direct relationship between theory and practice, since one without the other does not allow for the comprehensive training of the student. In this case, incorporating knowledge of industrial costs, theory provides the conceptual framework for praxis to be applied and validated in different industrial contexts; this interrelationship is fundamental to promoting inclusion and transformation in engineering pedagogy.

An intervention that merges theory with practice allows for critical reflection. In this scenario, comprehensive training in the curricular and practical content of the industrial costs course allows future industrial engineers to make sound decisions when evaluating the feasibility of a project's execution [18]. In this context, the results provided by research in this area highlight the need to question the pedagogical practices of each engineering teacher, where catharsis allows them to evaluate the approaches and strategies used in the classroom. This cognition allows them to detect and address the difficulties that may arise in the real context [18].

The abstract nature of industrial cost concepts, taught without connection to real contexts, makes it difficult for students to link theory with practice, limiting their deep understanding [19]. This implies understanding the social work that, as teachers, cannot be ignored, reflecting on the responsibility for educational transformation, and developing an environment committed to inclusion [20].

1.2 Pedagogical challenges between theory and practice

According to the changes made over the years and the need for innovation to transmit knowledge, humanity is innovating more and more every day. This is why traditional expository methodologies tend to be demotivating. In contrast, active approaches have been shown to increase student motivation and make academic knowledge more meaningful in relation to its practical application [21].

In line with the above, adopting teaching strategies that promote higher cognitive skills has become an important pillar for strengthening education around the world. Human beings are learning by leaps and bounds, and self-learning is very noticeable in this society. This is why engineering has focused on channeling most resources into ICT-based learning, since knowledge is the union of science and technology. Over time, students reevaluate their own knowledge and acquire new knowledge to stay at the forefront of today's essential training processes [22].

For this reason, traditional industrial cost teaching is currently more theoretical, disconnected from the industrial world of training processes. In contrast, recent studies report that the incorporation of active methodologies in engineering, such as the PBL methodology, improves student participation and academic performance in higher education [23]. The above shortcomings are evidence supporting a shift from the traditional paradigm to more dynamic, student-centered teaching strategies. In particular, the use of virtual environments combined with PBL is emerging as a concrete response to these shortcomings, promoting experiential learning that connects theory with practice and overcomes the deficiencies of traditional methodologies in teaching industrial costs.

1.3 Active teaching strategies: (PBL) and (PBL) as drivers of learning

In line with the needs outlined above, Problem-Based Learning (PBL) offers a suitable methodology for teaching industrial costs, where the link between theory and practice is reflected in the collaborative resolution of complex problems in real contexts [24].

As pointed out in [25], Problem-Based Learning (PBL) has become a basic and indispensable tool worldwide, enabling real-time communication of information and data between individuals and companies, making these operational processes more effective, and providing up-to-date information that allows for competitiveness in a rapidly advancing world. In Colombia, the implementation of semester-long classroom projects has proven to be an effective teaching strategy in engineering, as it allows students to integrate technical knowledge in simulated or real scenarios and develop practical solutions to problems in their environment [27]. Likewise, [23], [24] point out that a methodological management protocol must be in place, therefore, highly trained professionals are required in each of the processes; resource and project management must be seen as a tool that can be an advantage or disadvantage for science, from which it follows that the success of a project is decisive.

As pointed out in [22] and [23], Problem-Based Learning (PBL) and Project-Based Learning (PBL) have become a basic and indispensable tool worldwide, allowing real-time communication of information and data between people and companies, making these operational processes more effective and providing up-to-date information that allows for competitiveness in a rapidly advancing world. In Colombia, the implementation of semester-long classroom projects has proven to be an effective pedagogical strategy in engineering, as it allows students to integrate technical knowledge in simulated or real scenarios and develop practical solutions to problems in their environment [24]. Likewise, [22], [23] point out that a methodological management protocol must be in place, therefore, highly trained professionals are required in each of the processes; resource and project management must be seen as a tool that can be an advantage or disadvantage for science, from which it follows that the success of a project is decisive.

According to [26], contextualized teaching strategies such as simulating industrial cost processes in real contexts allow students to develop an understanding of complex processes, helping them in their decision-making. In the context of industrial engineering, applying these methodologies allows students to gain greater clarity about the difficulties that may arise in real contexts and to apply different solutions in a safe virtual environment. To obtain excellent results, this support must be led by the teacher, and it is here that these experiences allow for the development of soft skills such as teamwork and communication [26]. These dynamic interactions are essential in industrial engineering studies, as they allow for the consolidation of knowledge and the construction of meaningful learning experiences.

In this scenario, research in the field of engineering has shown that the combination of PBL and PBLR methodologies promotes student motivation, with real-world practices being the points of greatest engagement, resulting in lower student dropout rates and higher levels of student satisfaction and enjoyment of learning, these factors being key to the success of engineering professionals [27]. Likewise, those who have worked with these methodologies demonstrate mastery of their professional skills in their work environments, indicating that they have greater confidence when applying technical and theoretical knowledge in practical settings [28].

However, the use of PBL methodology presents challenges for teachers in its application, requiring them to take action based on their expertise to guide students through complex projects and make effective use of the available technological tools, leading the different projects to successful outcomes. Under these circumstances, implementing learning communities that strengthen collaboration between teachers and students is key to the exchange of knowledge, facilitating the adaptation and constant improvement of these methodologies in the classroom [29].

1.4 Student evaluation and perception as a tool for continuous improvement

In engineering, student evaluation and perception are a tool that allows for feedback and continuous improvement of the degree program's training processes in order to focus knowledge on planning, preventing, and verifying the processes carried out in a project [16], [30]. Likewise, it is vitally important to evaluate each technique applied to bring technical knowledge from practice to the area of performance.

This is why evaluation is so important, as assessment from the teaching point of view should be seen as a tool that not only measures knowledge but also teaches and trains [31]. In this scenario, surveys, interviews, and focus groups are ideal for gathering student perceptions, where feedback is key to identifying which methods worked well and which should be modified or eliminated from the learning process [32].

It is necessary to gather student perceptions on an ongoing basis, making them an active agent of change, where their assessment is a factor in academic and motivational improvement [33]. Evaluating the methodologies taught by teachers within the student context by these actors allows for the transformation of the classroom environment, where student confidence will be reflected in increased motivation and self-confidence. When an approach is student-centered, it promotes more participatory learning with academic excellence [34].

Under this premise, [35] points out that evaluation should promote continuous training and updating of teachers, and the results of the application of these tools should be geared toward improving professional teaching performance. Likewise, [36] states that it is necessary to encourage teachers to improve the quality of the content and tools they use in the classroom, with the intention of applying good practices that enrich the educational context, where the joint commitment of students and teachers improves the educational experience, creating a more fair and inclusive system.

Therefore, this article focuses on studying successful training experiences with the PBL methodology at the Francisco de Paula Santander University [13] and on analyzing research on student perception in university contexts in virtual environments [14]. These findings will enable other researchers to create contextualized teaching strategies that impact engineering degrees and strengthen the skills specific to the subject of industrial costs, promoting continuous improvement in the learning process.

According to [37], this type of research stands out for its adaptability and flexibility, as it allows numerical data to be collected according to the needs of the study, which enabled the systematic identification of patterns, trends, and levels of acceptance of the methodologies used by teachers in this subject.

2. MATERIALS AND METHODS

Research methodology is a way of systematically solving what is known as the “research problem” and can be defined as the theory of how research should be conducted. Research methodology consists of a series of steps that a researcher takes to study their research problem, together with the logic behind them [38]. For this research, methodology is the part of the research process in which the set of techniques and methods to be used to carry out the actions related to the achievement of a research project is decided [37].

At the same time, the research is descriptive, in that its objective is to measure a series of characteristics of the population under study, ensuring that data is collected in accordance with the existing reality. To confirm this [39], they point out that: “descriptive studies seek to specify the important properties of individuals, groups, communities, or any other phenomenon that is subject to analysis.”

To this end, the study adopted a non-experimental cross-sectional design, as a 16-item Likert-type questionnaire with a five-level scale was administered to a sample of 45 students enrolled in the industrial costs course of the industrial engineering program at Francisco de Paula Santander University, without any manipulation of variables by the researcher. This methodology allowed for observation at a single point in time, where the perceptions of students were collected from the second semester of 2023 to the first semester of 2024.

Therefore, it focused on a quantitative approach, since the researcher's intention was to collect and analyze statistical data to evaluate industrial engineering students' perceptions of the pedagogical strategies implemented by teachers in the industrial costs course, focusing particularly on Project-Based Learning (PBL), case studies, and complementary tools.

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A five-point Likert scale was used, with the following response ranges: Strongly disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), and Strongly agree (5). This type of assessment provided details on students' perceptions of the use of PBL-based strategies and case studies, as well as complementary strategies.

The measurement instrument was a 16-item Likert-type questionnaire, designed based on recent studies in engineering education, which recommend this format for its ability to capture quantifiable perceptions of pedagogical strategies and active methodologies. The instrument was validated through expert judgment and a preliminary pilot study with ten students, a recognized procedure for ensuring content validity and semantic clarity.

Reliability was estimated using Cronbach's alpha coefficient (α = 0.89), considered statistically adequate for scales with more than ten items. The data were processed using SPSS v.26 software, applying descriptive statistics (frequencies, means, and standard deviations) to analyze students' perceptions of the dimensions: PBL and case studies and complementary strategies.

Given the sample size of 45 students, no advanced inferential tests were applied, a decision that was methodologically consistent with this being a descriptive-exploratory study.

Likewise, the test administration process was carried out virtually using Google Forms, and the confidentiality of the participants was respected by obtaining their informed consent. After collecting the information, it was tabulated according to a quantitative-descriptive approach, which included calculating frequencies, percentages, and measures of central tendency for each item, thus facilitating a clear visualization of patterns and allowing the strategies most highly valued by the sample to be identified.

The inclusion criteria established that the sample must belong to the industrial engineering program and have taken the industrial costs course using the PBL methodology. They must also have actively participated in applied projects throughout the second semester of 2023 to the first semester of 2024. The 16 items of the Likert-type questionnaire were distributed across two important dimensions:

Dimension 1: Strategies based on PBL and case studies (10 items)
Dimension 2: Complementary strategies (6 items)

3. DISCUSSION AND RESULTS

Below are the results of the tabulation of the collected data. The information was classified according to the following dimensions: PBL-based strategies and case studies, and complementary strategies, providing a conclusive perspective on how these methodologies impact the learning process of the industrial costs course in the industrial engineering program. In addition, demographic variables (age, gender, and semester) were tabulated and included to characterize the sample and contextualize the comparison between dimensions.

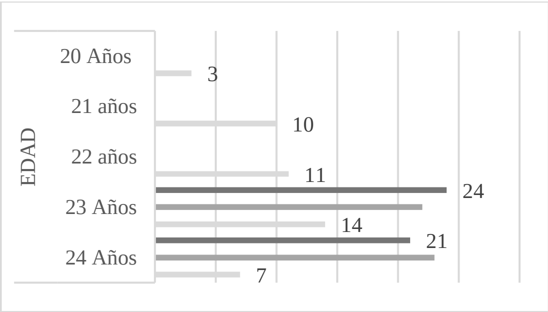

Fig. 1. *Datos Demográficos – Edad*
Fuente: *elaboración propia.*

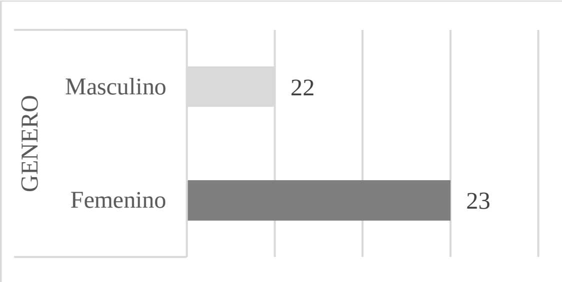

***Fig. 2**. Datos Demográficos – Género*
***Fuente:** elaboración propia.*

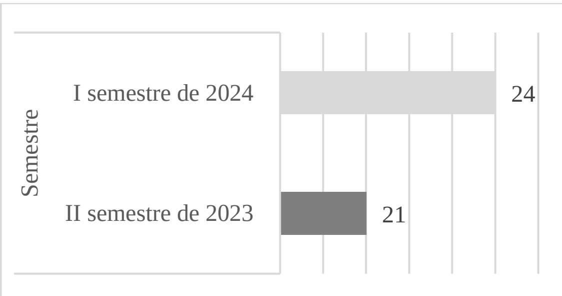

***Fig. 3**. Datos Demográficos – Semestre*
***Fuente:** elaboración propia.*

The demographic characterization of the sample showed a higher participation of students aged 23 and 24 (24 and 21 cases, respectively), followed by the groups aged 22 (11), 21 (10), and 20 (3). In terms of gender, the distribution was balanced, with 23 women and 22 men, reflecting an equitable representation of the surveyed population. Regarding the academic semester, there was a slight predominance of students from the first semester of 2024 (n=24) compared to the second semester of 2023 (n=21), which allowed for the collection of perceptions from two consecutive cohorts within the Industrial Engineering program.

According to the results obtained from the student perception questionnaire, there is a predominance of acceptance of the use of the PBL methodology and case studies; 93–96% responded "agree/strongly agree," with averages between 4.71 and 4.96. The most notable value is the variable: "identifies key variables in cost allocation during practical exercises." Another variable that stands out in this "information gathering" was the understanding of industrial cost concepts thanks to the development of applied projects. The above perceptions confirm the acquisition of theoretical content and its use in real contexts.

Likewise, the lowest items were: PBL activities helped them to promote their autonomy and critical thinking, and the assessment rubrics were clear and consistent with the project objectives. In this context, students clearly expressed that they still have difficulties in decision-making and believe that the instrument should be readjusted to be in line with the project objectives and thus obtain a broader view of students' perceptions regarding the use of PBL methodology in the industrial costs course in the engineering program.

In summary, the general perception of students is favorable regarding the use of PBL methodology and case studies; however, adjustments need to be made to the activities used to promote autonomy and critical thinking among this population.

Likewise, the results obtained from the dimension of the use of complementary strategies show a representative assessment. The highest-rated items were "the practical assessments were consistent with the teaching strategies used," "the comparisons between costing methods (ABC, standard) were clear and useful," and "the use of concept maps facilitated the organization of key ideas." Although these assessments were widely accepted by the sample, they have lower effectiveness values than those obtained in the application of the PBL methodology and case studies; this data is relevant for the researcher's conclusions. In the context of strategies to be improved, independent bibliographic reading stands out. Although positive, it ranks below the rest and requires more guidance to better connect with the tasks and decisions of the industrial costing course. Overall, this dimension enhances the application and organization of knowledge and leaves the task of strengthening academic reading to accompany practice.

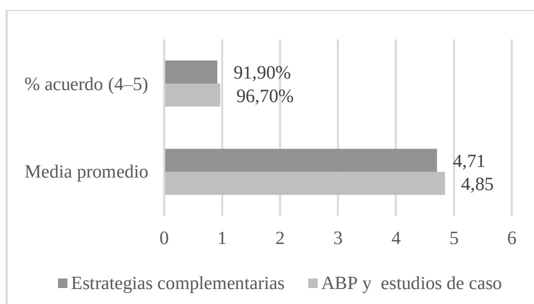

***Fig. 4**. Comparación de Dimensiones*
***Fuente:** elaboración propia.*

Student perception is very high overall (Global M=4.79; 94.9%). Within this, the PBL methodology and case studies lead (M=4.85; 96.7%), above complementary strategies (M=4.71; 91.9%). The relative advantage of these methodologies confirms the advantages of applying PBL methodology in engineering contexts, in the specific case of this research, its use in the subject of industrial costs.

Table 1: *Key items (strengths according to average)*

Ranking	Dimension	Ítem	Key idea	Average
1	Project-Based Learning (PBL) and Case Studies	4	Identify key variables in cost allocation during practical exercises.	4,96
2	Project-Based Learning (PBL) and Case Studies	1	Better understand industrial cost concepts through the development of applied projects.	4,91
3	Project-Based Learning (PBL) and Case Studies	2	Analyzing real cases allowed me to connect costs with business decisions.	4,89
4	Complementary strategies	12	The assigned readings strengthened my theoretical understanding.	4.58
5	Complementary strategies	14	Individual activities allowed me to reflect on my learning.	4.67
6	Complementary strategies	11	In-class debates helped me compare different cost-management approaches.	4.69

Source: *own elaboration*

Note: Opportunities for improvement are defined relatively in relation to the highest scores in the set. All items show high ratings (≥4.58); therefore, opportunities are interpreted as fine adjustments, not weaknesses.

In Table 1, the items highlighted, according to the average, belong to the PBL methodology. The results show significant improvements in the learning of theoretical concepts of industrial costs and in the application of practical exercises. However, the complementary strategies must be readjusted so that they can make a direct connection with the practical tasks.

Table 2: *Items with room for improvement (relative)*

Ranking	Dimension	Ítem	Key idea	Average
4	Complementary strategies	12	The bibliographic readings reinforced my theoretical understanding.	4.58
5	Complementary strategies	14	The individual activities allowed me to reflect on my learning.	4.67
6	Complementary strategies	11	The class discussions helped me to compare different approaches to cost management.	4.69

Source: *own elaboration*

The results confirm clear strengths in identifying cost variables, understanding projects, and linking costs to decisions (averages 4.89–4.96). In contrast, and only relatively speaking, individual reading and reflection activities scored slightly lower (4.58–4.69), suggesting specific opportunities for optimization without compromising overall high performance.

The results show a positive perception of active teaching strategies among students, highlighting the value of Project-Based Learning (PBL), real-life case studies, and the use of digital tools. These methodologies were recognized as useful for applying knowledge in real-life contexts.

Although complementary strategies such as practical assessments and concept maps were also well regarded, their impact was slightly lower than that of PBL. However, this methodological variety reinforces the construction of meaningful learning from different perspectives.

These findings are consistent with recent studies. According to [40], PBL promotes the integration of theory and practice, enhancing decision-making and motivation. The preference for real-life cases supports the findings of [33], while the use of digital tools confirms the findings of [41] by facilitating a deeper understanding of accounting and industrial processes.

According to [42], the assessment of debates and concept maps encourages argumentation and critical thinking among students. Likewise, the link between motivation and academic performance was evident in the use of the PBL methodology, highlighting the need for teacher support in the process of applying practices in real contexts.

In this context, the link that should exist between collaborative work and individual work is also highlighted, as this integration strengthens the soft skills and autonomy of engineering students [43]. In line with the above, the positive acceptance of the PBL methodology by students confirms what has been noted in other studies, where its continued use is directly linked to comprehensive training and the development of cross-cutting skills [44].

Finally, the evidence found in this research reinforces the need to integrate the PBL methodology as an approach to solving problems in authentic/simulated business situations, promoting evidence-based decisions and the development of professional and digital skills.

4. CONCLUSIONS

The research showed how PBL transforms learning in the subject of industrial costs. Project-Based Learning (PBL) was particularly valued by students, who highlighted its usefulness in understanding complex concepts, making decisions, and connecting theory with practice. Applied projects and case studies were key elements in achieving a deeper understanding; these activities were applied to students and correspond to the items in the "PBL and case studies" section of the questionnaire. The study addressed PBL only; it does not generalize to other methodologies that were not evaluated.

Although complementary strategies were less widely accepted, they were recognized as useful in training, contributing to PBL through debates, concept maps, and practical activities.

Finally, in the subject analyzed, it is recommended to maintain and strengthen PBL, incorporating technology as support. The importance of constant feedback, clear rubrics, and spaces where students can develop autonomy in simulated productive scenarios is also highlighted. The activities described are specific to the subject at this institution; regional representativeness is not inferred.

REFERENCES

[1] LK Tartibu, "Engineering Optimization," in *Multi-objective Optimization Techniques in Engineering Applications*, *Studies in Computational Intelligence*, vol. 1184. Cham, Suiza: Springer, 2025, pp. 1–36.

[2] T. Rüütmann, "Engineering pedagogy and engineering educators' competency model for effective teaching and learning STEAM," *Problems of Education in the 21st Century*, vol. 81, no. 4, pp. 531–543, 2023, doi: 10.33225/pec/23.81.531.

[3] V. F. C. Servant-Miklos 6 A. Kolmos, "Student conceptions of problem and project based learning in engineering education: A phenomenographic investigation," *J. Eng. Educ.*, vol. 111, no. 4, pp. 792-812, 2022, doi: 10.1002/jee.20478.

[4] Education & Training Evaluation Commission (ETEC), *Key Learning Outcomes for Industrial Engineering* Program, ver. 1.1, 2023. https://f.etec.gov.sa/j/Industrial_Engineering.pdf?utm

[5] GA Balabarca-Poves, FA Caycho-Valencia, N Hanco-Pichuilla & C Lezama-Cuellar, "Estrategias para el desarrollo de la práctica reflexiva docente en Iberoamérica," *Rev. Arbitrada Interdiscip. Koinonía*, vol. 9, no. 1, pp. 4–21, 2024, doi: 10.35381/r.k.v9i1.3550.

[6] Y. Gutiérrez-Martínez, R. Bustamante-Bello, S. A. Navarro-Tuch, AA López-Aguilar, A. Molina, & I Álvarez-Icaza, "A Challenge-Based Learning Experience in Industrial Engineering in the Framework of Education 4.0," Sustainability, vol. 13, no. 17, art. 9867, 2021, doi: 10.3390/su13179867

[7] D Cardona-Valencia & FA Betancur-Duque, "Percepción estudiantil sobre el uso de metodologías no tradicionales en la enseñanza de la ingeniería", *DYNA*, vol. 89, no. 222, pp. 98-105, 2022 doi: 10.15446/dyna.v89n222.101504

[8] MM Thottoli, MA Islam, ABM Abdullah, MS Hassan, & S Ibrahim, "Enricher learning: Bridging the gap between academics and practicing accounting professionals," *Journal of Education for Business, vol*. 99, no 5, pp. 300–311, 2024, doi: 10.1080/08832323.2024.2366787

[9] R Gil-Galván, I Martín-Espinosa & FJ Gil-Galván, "Percepciones de los estudiantes universitarios sobre las competencias adquiridas mediante el aprendizaje basado en problemas," *Educación XX1*, vol. 24, no. 1, pp. 271–295, 2021, doi: 10.5944/educxx1.26800.

[10] V Sukackė, A. OP de C. Guerra, D Ellinger, V Carlos, S. Petronienė, L. Gaižiūnienė, *et al.*, "Towards Active Evidence-Based Learning in Engineering Education: A Systematic Literature Review of PBL, PjBL, and CBL," *Sustainability*, vol. 14, no. 21, art. 13955, 2022.

[11] R Rodríguez, L Angulo-Sánchez & N Leitón-Sancho, "Desarrollo de la metodología de aprendizaje basado en problemas en un curso de ingeniería," *Revista Digital Educación en Ingeniería*, vol. 15, no. 30, pp. 26–33, 2020, doi: 10.26507/rei.v15n30.1122.

[12] HA Lopera, E Gutiérrez-Velásquez & N Ballesteros, "Bridging the Gap Between Theory and Active Learning: A Case Study of Project-Based Learning in Introduction to Materials Science and Engineering," *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje (IEEE-RITA)*, vol. 17, no. 2, pp. 160–169, may. 2022, doi: 10.1109/RITA.2022.3166862.

[13] Universidad Francisco de Paula Santander (UFPS), "Plan de estudios – Ingeniería Industrial (incluye 'Costos Industriales')," 2021. [En

línea]. Disponible: https://ww2.ufps.edu.co/public/archivos/oferta_academica/a500ec615adbed970963f554817367f6.pdf

[14] AF Jaimes-Cuadros, RI Laguado-Ramírez & EG Florez-Serrano, "Cost management in industrial operations," *Int. J. Eng. Res. Technol.*, vol. 14, no. 6, pp. 555–561, 2021.

[15] JM Herrera-Mantilla, "Estrategias pedagógicas para la enseñanza del proceso de exportación en el programa de comercio internacional de la Universidad Francisco de Paula Santander," tesis de especialización, Univ. Francisco de Paula Santander, San José de Cúcuta, Colombia, 2022. [En línea]. Disponible: https://repositorio.ufps.edu.co/handle/ufps/8794

[16] S Pertuz, "Perception of Engineering Students on Remote Teaching with the Flipped-Classroom Strategy," *Rev. Ingenierías Univ. de Medellín*, vol. 20, no. 39, pp. 231–250, 2021, doi: 10.22395/rium.v20n39a13.

[17] R Couselo, E. Williams y M. Pendón, "Las finanzas en la formación de ingenieros," en *V Jorn. sobre las Prácticas Docentes en la Univ. Pública*, La Plata, Argentina, 2023, pp. 1–11.

[18] JH Lárez-Hernández & RA Sobarzo-Ruiz, "La práctica reflexiva docente y su relación con las competencias investigativas en la formación inicial del profesorado," *Educ. y Ciudad*, no. 47, art. e3191, 2024, doi: 10.36737/01230425.n47.2024.3191.

[19] RI Laguado, RP Ramírez & FY Hernández, "Students' perception of an engineering program on student mobility and its impact on integral formation," *J. Phys.: Conf. Ser.*, vol. 1388, art. 012049, 2019, doi: 10.1088/1742-6596/1388/1/012049.

[20] JD Torres, D Acevedo & PM Montero, "Proyectos de Aula Semestrales como Estrategia Pedagógica para la Formación en Ingeniería," *Form. Univ.*, vol. 9, no. 3, pp. 23–30, 2016.

[21] S Lavado-Anguera, PJ Velasco-Quintana & MJ Terrón-López, "Project-Based Learning (PBL) as an Experiential Pedagogical Methodology in Engineering Education: A Review of the Literature," *Education Sciences*, vol. 14, no. 6, art. 617, 2024, doi: 10.3390/educsci14060617.

[22] M Ramírez de Dampierre, MC Gaya-López & PJ Lara-Bercial, "Evaluation of the Implementation of Project-Based Learning in Engineering Programs: A Review of the Literature," *Education Sciences*, vol. 14, no. 10, art. 1107, 2024, doi: 10.3390/educsci14101107.

[23] H. A. Lopera, E. Gutiérrez-Velasquez, & N. Ballesteros, "Bridging the Gap Between Theory and Active Learning: A Case Study of Project-Based Learning in Introduction to Materials Science and Engineering," IEEE *Revista Iberoamericana de Tecnologías del Aprendizaje*, vol. 17, no. 2, pp. 160–169, 2022, doi: 10.1109/RITA.2022.3166862

[24] AT Galán, "Percepción del alumnado del aprendizaje basado en proyectos (ABP STEM)," *Cuest. Pedagóg.*, vol. 2, no. 33, pp. 18–33, 2024, doi: 10.12795/CP.2024.i33.v2.10.

[25] J Ruiz-Meza, M Castellanos-Adarme, F Alzate-Ortiz & A Flórez-Gutiérrez, "Aplicación del aprendizaje basado en problemas en el programa de Ingeniería Industrial: caso de estudio aplicado en el curso de Gestión de Cadenas de Suministro," *Rev. Científica*, vol. 41, no. 2, pp. 169–183, 2021, doi: 10.14483/23448350.16248.

[26] PE Lerzo, HL Alcar, D Mielnicki & L Britos, "Aprendizaje Basado en Proyectos (ABP) en materias avanzadas de ingeniería: análisis de su aplicación e impacto en diferentes asignaturas en universidades de la República Argentina," en *Encuentro Int. de Educ. en Ingeniería (EIEI ACOFI)*, 2022, doi: 10.26507/paper.2242.

[27] I Barragán-Arias & ML Barrera-Pérez, "Proyecto de aula para la enseñanza de las ciencias básicas en ingeniería," en *Encuentro Int. de Educ. en Ingeniería (EIEI ACOFI)*, 2023, doi: 10.26507/paper.2857.

[28] F Muñoz La Rivera, N Muñoz, S Montecinos, M Proboste-Martínez & J Mora-Serrano, "Implementación de una simulación en realidad virtual para la inspección formativa de puentes," en *Encuentro Int. de Educ. en Ingeniería (EIEI ACOFI)*, 2024, doi: 10.26507/paper.3768.

[29] R Rodríguez, L Angulo-Sánchez & N. Leitón-Sancho, "Desarrollo de la metodología de aprendizaje basado en problemas en un curso de ingeniería," *Rev. Digit. Educ. en Ing.*, vol. 15, no. 30, pp. 26–33, 2020, doi: 10.26507/rei.v15n30.1122.

[30] AG Sunitha & AS Rao, "Program assessment and evaluation for continuous improvement of course outcomes," *Journal of Engineering Education Transformations*, vol. 34, no. 3, pp. 41–48, 2021. https://share.google/aZBzRmCxTLbRrZo7U

[31] PE Lerzo, HL Alcar, D Mielnicki & L Britos, "Aprendizaje Basado en Proyectos (ABP) en materias avanzadas de ingeniería: análisis de su aplicación e impacto en diferentes asignaturas en universidades de la República Argentina," en *Encuentro Int. de Educ. en Ingeniería (EIEI ACOFI)*, 2022, doi: 10.26507/paper.2242.

[32] CE Beloqui, *Comunidades de Aprendizaje: Informe final*. SUMMA, 2024. [En línea]. Disponible: https://summaedu.org/wp-

content/uploads/2025/06/02.-Informe-final-comunidades-de-aprendizaje.pdf

[33] ABET, "Criteria for Accrediting Engineering Programs, 2025–2026," 2024. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/

[34] AT Galán, "Percepción del alumnado del aprendizaje basado en proyectos (ABP STEM)," *Cuestiones Pedagógicas*, vol. 2, no. 33, pp. 185–202, 2024, doi: 10.12795/CP.2024.i33.v2.10.

[35] J S Santana-Martel, M. L. Pérez-Navío & Á. P. Carrasco-Aguilar, "Cocreación de la evaluación mediada por tecnología en educación superior: percepciones del profesorado," *Rev. Fuentes*, vol. 25, no. 2, pp. 201–220, 2023, doi: 10.1344/der.2024.45.204-213.

[36] F Rodríguez & MJ Nunes, "Aprendizajes en proceso de co-creación: eficacia de una experiencia educativa en la enseñanza superior," *Espiral. Cuadernos del Profesorado*, vol. 17, no. 45, pp. 75–88, 2024, doi: 10.31637/epsir-2024-601.

[37] S Valbuena & A Rodríguez-Pedraza, "La co-creación y las comunidades virtuales de aprendizaje: análisis bibliométrico," *Ánfora*, vol. 32, no. 58, pp. 200–229, 2025, doi: 10.30854/anf.v32.n58.2025.1122.

[38] JC Ramírez-Montañez & RJ Calles-Moreno, *Manual de metodología de la investigación en negocios internacionales*, 1ª ed. Bogotá, Colombia: ECOE Ediciones, 2021.

[39] G Guerrero-Dávila & C Guerrero Dávila, *Metodología de la investigación*. México: Grupo Editorial Patria, 2020.

[40] Y Turra-Marín, CP Villagra-Bravo, ME Mellado-Hernández & OA Aravena Kenigs, "Diseño y validación de una escala de percepción de los estudiantes sobre la cultura de evaluación como aprendizaje," *RELIEVE - Rev. Electrón. Investig. Eval. Educ.*, vol. 28, no. 2, art. 9, 2022, doi: 10.30827/relieve.v28i2.25195.

[41] H González-González & J Viáfara-González, "El aprendizaje basado en proyectos como estrategia para la formación profesional en ingeniería," *Revista Educación en Ingeniería*, vol. 17, no. 33, pp. 45–58, 2022, https://doi.org/10.26507/rei.v17n33.1456

[42] M López-Castro & D Jiménez, "Mapas conceptuales y debates como estrategias para el pensamiento crítico en educación superior," Revista Iberoamericana de Educación, vol. 84, no. 1, pp. 123–138, 2020, https://doi.org/10.35362/rie841456

[43] RI Laguado-Ramírez, "Neuromarketing como herramienta de planificación en la gestión municipal," *Revista Colombiana de Tecnologías de Avanzada*, vol. 30, no. 30, p. 2753, 2017, doi: https://doi.org/10.24054/16927257.v30.n30.2017.2753

[44] R. I. Laguado-Ramírez, E.G. Florez-Serrano, & F. Y. Hernández-Villamizar, "Motivation and performance of students of an engineering program in the realization of industrial practices," *Journal of Physics: Conference Series*, vol. 1126, Art. no. 012043, 2018, doi: https://doi.org/10.1088/1742-6596/1126/1/012043