PANORAMA
ISSN: 1909-7433
ISSN: 2145-308X
ednorman@poligran.edu.co
Politécnico Grancolombiano
Colombia

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Duque Cardona, Valentina; Largo-Taborda, Wilson Alejandro
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PANORAMA, vol. 15, núm. 28, 2021
Politécnico Grancolombiano, Colombia
Disponible en: https://www.redalyc.org/articulo.oa?id=343965146027
DOI: https://doi.org/10.15765/pnrm.v15i28.1821
Institución Universitaria Politécnico Grancolombiano
Institución Universitaria Politécnico Grancolombiano

Artículos de investigación científica y tecnológica

DEVELOPING SCIENTIFIC COMPETENCES WITH THE IMPLEMENTATION OF PROBLEM-BASED LEARNING (PBL) IN FIFTH GRADE STUDENTS AT INSTITUTO UNIVERSITARIO DE CALDAS (MANIZALES)

DESARROLLO DE LAS COMPETENCIAS CIENTÍFICAS MEDIANTE LA IMPLEMENTACIÓN DEL APRENDIZAJE BASADO EN PROBLEMAS (ABP) EN LOS ESTUDIANTES DE GRADO QUINTO DEL INSTITUTO UNIVERSITARIO DE CALDAS (MANIZALES)

PANORAMA, vol. 15, núm. 28, 2021

Politécnico Grancolombiano, Colombia

Recepción: 08 Septiembre 2020
Aprobación: 21 Octubre 2020

DOI: https://doi.org/10.15765/pnrm.v15i28.1821

Redalyc: https://www.redalyc.org/articulo.oa?id=343965146027

Valentina Duque Cardona valentina.duque@ucm.edu.co
Instituto Universitario de Caldas, Colombia
Wilson Alejandro Largo-Taborda wlargo@ucm.edu.co
Universidad de Caldas., Colombia

Abstract: Problem-Based Learning (PBL) is a methodological strategy that offers teachers and students a group of activities that seek to make learning active, dynamic and meaningful; this strategy's starting point comprises problems or issues present in students' daily lives, aimed at achieving meaningful learning. The objective of this research was implementing PBL to develop scientific competences in fifth grade students in the topic of the respiratory system. The methodology had a qualitative approach, following a research-action method with an experimental group and a control group at Instituto Universitario de Caldas, in the city of Manizales. Information collection considered the level of students' appropriation of scientific competences, to proceed with the implementation of PBL in teaching the topic of the respiratory system and thus evaluate the scientific competences developed in the fifth graders. By way of conclusion, fifth grade students at Instituto Universitario de Caldas showed progress in the appropriation and development of scientific competences, a more conscious and meaningful process led them to attain learning from experience.
PBL; scientific competencies; pedagogical strategy; educational innovation; didactic unit.
https://doi.org/10.15765/pnrm.v15i28.1821

Keywords: PBL, scientific competencies, pedagogical strategy, educational innovation, didactic unit.

Resumen: El Aprendizaje Basado en Problemas (ABP) es una estrategia metodológica que presenta al docente y al estudiante un grupo de actividades que buscan que el aprendizaje sea activo, dinámico y significativo; esta estrategia tiene como punto de partida situaciones problémicas que surgen de la cotidianidad del estudiante, logrando así un aprendizaje con sentido. Para el desarrollo de la investigación se tuvo como objetivo la implementación del ABP para el desarrollo de las competencias científicas para los estudiantes de grado quinto en la enseñanza del sistema respiratorio. La

metodología implementada se dio desde el enfoque cualitativo, método investigación-acción, con un grupo experimental y un grupo control, en el Instituto Universitario de Caldas, de la ciudad de Manizales. Para la recolección de la información se tuvo en cuenta el nivel de apropiación que tienen los estudiantes sobre las competencias científicas, para luego llevar a cabo la implementación del ABP en la enseñanza de la temática relacionada con el sistema respiratorio y así evaluar el desarrollo de las competencias científicas en los estudiantes de dicho grado. A modo de conclusión, los estudiantes de grado quinto del instituto Universitario de Caldas presentaron un avance en la apropiación y desarrollo de las competencias científicas, siendo un proceso más consciente y significativo, logrando un aprendizaje desde la experiencia y las propias vivencias.

Palabras clave: Aprendizaje Basado en Proyectos, Competencias científicas, estrategia pedagógica, innovación educativa, unidad didáctica.

INTRODUCTION

This research originates from the need to find strategies to deliver natural sciences topics in a fifth grade classroom in a way that alters the classroom's dynamic to solidify scientific competences evaluated by the Ministry of National Education's (MEN, for its Spanish acronym) Saber 5° test (Diaz, 2006; Escobedo, 2001).

PBL emerges as an alternative to address this issue and to break the institution's prevailing paradigm of traditional education (Garcia, 1999; Guerrero, 2019). PBL links students' everyday life with the concepts that are typical of each grade, in this particular case, of the fifth grade (Gil & De Guzman, 1993).

Sastre and Araujo (2018) explain that PBL is regarded as an innovative approach in training and academic processes occurring nowadays. Its importance is discernible in primary, secondary and high school education, with more intensity in the latter, i.e., it has become a possibility for teachers to connect concepts with experience and practice (Camacho, Casilla & Finol, 2008).

Consequently, Betancourt (2006) and Perez (2015) highlight the importance of PBL in developing students' autonomy since its focus is on students instead of teachers. Students' active and permanent role purports to get them in charge of their learning. Thus, students' motivation increases based on the fact that they become part of the solution to the problems related to reality and context (Giraldo, Zuluaga & Naranjo, 2020).

The backdrop of the project was the fifth grade at Instituto Universitario de Caldas; students' age ranges between 9 and 12 years, a total sample of 81 students was divided in two groups, 5A and 5B, an experimental and control group, respectively, to compare their results in the pre-test as a diagnosis, and in a post-test following the implementation of the experimental group's strategy (Lopez, Marulanda & Piedrahita, 2011; Martinez, 2011).

The PBL strategy was applied through a didactic unit about the topic of the respiratory system; the strategy was selected because it allowed gathering the eight steps of PBL in its structure, according to Morales and Landa (2004). A significant result showed that PBL positively impacted the development of scientific competences, also, of analytical capacities

and interpretation of all sorts of texts, which in turn has a direct impact on motivation, curiosity and the likelihood to build and develop a set of basic cognitive, procedural and attitudinal skills that will provide students awareness of their learning (Gutierrez et al., 2018; Marin, Parra, Burgos & Gutierrez, 2019).

In that regard, PBL gives students an active and critical role within their training process, they are in charge of proposing real solutions to real problems. Therefore, PBL favors the development of scientific competences: comprehensive use of scientific knowledge; inquiry and explanation of phenomena through a guided, organized and deliberate process; connection of concepts with a problem that must be solved by the student (Calderon, 2012).

DIDACTIC UNIT

According to Moreira (2010), didactic units allow a constant evaluation of processes that go hand in hand with students' work, in other words, planning, evaluation and execution of strategies used by teachers. Also, the structure of didactic units made room for the eight steps to execute PBL in elementary, as Morales and Landa (2004) suggest. These steps entail reading and analyzing a problem, brainstorming, listing things that are known and unknown, in addition to thinking about the problem and what its solution requires, making it indispensable to define the problem, as well as to obtain, analyze and present the results.

This research began with a bibliographic review, which gave input to the process and helped built the robust and concrete bases required to obtain reliable results. The pre and post-tests were produced in Google Forms, which enabled immediate statistic results of students' performance before and after the implementation of PBL (Fuente, Manzanares & Manzanares, 2006).

Questions in both tests were selected taking into account Alfarado's (2019) suggestions, the author provided elements to categorize questions according to the level of competence to be evaluated.

METHODOLOGY

The project's development was based on action research, its three fundamental steps go hand in hand with the specific objectives of this research: planning, implementing and evaluating; the qualitative approach was followed since it is useful to describe situations, actions and strategies observed in the classroom, also, it helped study the context and look for solutions to the proposed problem (Elliot, 1991).

Hernandez, Fernandez and Baptista (2010) describe the qualitative approach as a scenario in which interpretative practices allow understanding the world, making it visible, changing it and transforming it into a real or tangible scene, i.e., modifying it to notes, recordings, observations and documents. Therefore, researchers and participants discuss a problem that needs to be tackled, modified or evaluated, in an educational environment, in this particular case (Alvarez, 2003; Cuenya & Ruetti, 2010).

Participants were conveniently selected based on the close relationship with fifth graders as a teacher of natural science of the experimental group (41 students); the control group (40 students) had a different teacher, which used traditional teaching strategies. Groups are homogeneous in terms of applied methodological strategies, age groups, socioeconomic situations, educational facilities and level reached of the aforementioned scientific competences (Arteta et al., 2002; Coronado & Arteta, 2015). It must be emphasized that fifth graders are going through a time of academic changes, seeing as they are on their way to high school.

Three instruments were used to answer the problem question; the pre-test was used in an initial identification process, it was made up of nine questions that were categorized per academic competence to be evaluated and its three degrees of difficulty per ICFES' Saber 5° test; the didactic unit was implemented as an intervention mechanism within the experimental group; and the post-test, which followed the same mechanism as the pre-test.

COMPETENCE	LEVELS	No. OF QUESTIONS
INQUIRY	Minimum Satisfactory Advanced	3
COMPREHENSIVE USE OF SCIENTIFIC KNOWLEDGE	Minimum Satisfactory Advanced	3
EXPLANATION OF PHENONEMA	Minimum Satisfactory Advanced	3

Table 1.
Structure of the pre and post-test
Source: compiled by the authors (2020)

RESULTS

The Student's t-test available in Excel was used to analyze information, generate results and provide recommendations, it generated statistical comparisons between the control and experimental group for each of the tests applied. Results were as follows:

	Variable 1	*Variable 2*
Mean	16.11111	16.11111
Deviation	15.61111	18.61111
Typical error of the mean	0.677	0.688

Table 2
Results analysis using T-Student.
Source: compiled by the authors (2020).

As seen in the next illustration, the pre-test revealed that the control and the experimental groups are homogeneous, which means that they have no significant differences in terms of the level reached by students on scientific competences, which are at minimum level.

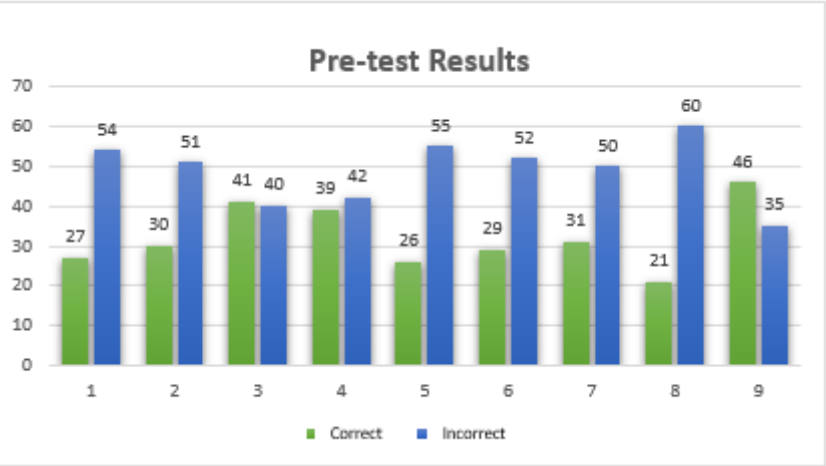


Illustration 1
Results of the diagnostic test.
Source: compiled by the authors (2020).

When the didactic unit was applied to the students in the experimental group, students displayed openness, enthusiasm and dynamism in the classroom, they were active actors in the teaching-learning process. Evidently, each step of the PBL gave students the necessary elements to respond to the suggested problem.

The post-test for both groups determined that after the implementation of the didactic unit, the experimental group made significant progress in content appropriation, being able to apply it in problems, thus enhancing the level of scientific competences.

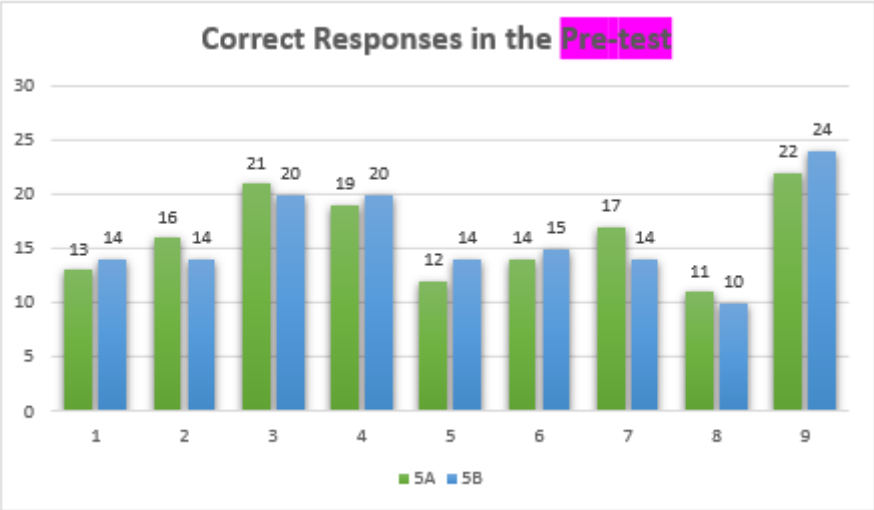


Illustration 2.
Correct responses in the post-test, control vs experimental group
Source: compiled by the authors (2020).

This illustration demonstrates great progress reflected in a difference in the means of the pre-test and the post-test. This is summed up as a positive variation for the experimental group in terms of scientific competences (associated with the implementation of the PBL strategy),

which addresses the significance of collaborative work and investigation, resulting in more trust in the students' knowledge and concepts (such as selection, search, organization and analysis of information they can access).

Likewise, it is important to add that the processes that took place until the implementation of the PBL were simultaneously conducted in both groups, i.e., work was done traditionally in a master class, yet virtually due to the contingency of the Covid-19 pandemic.

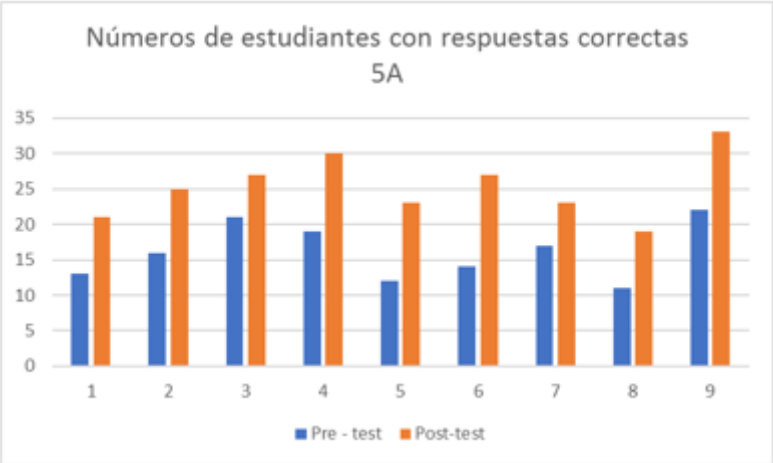
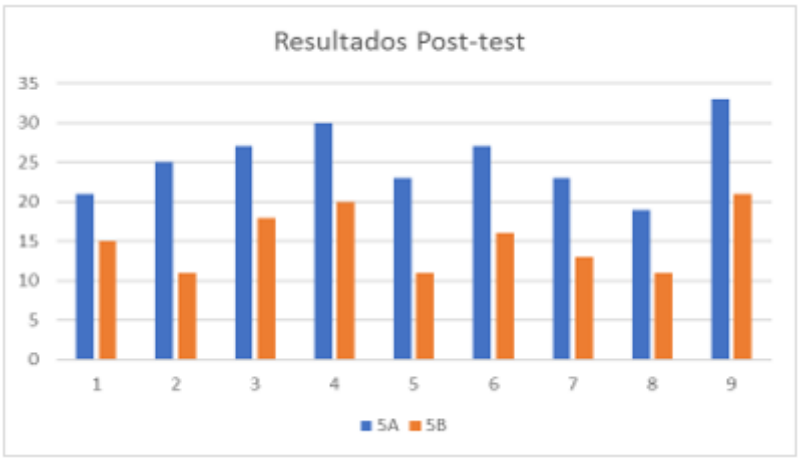


Illustration 3
Correct answers by students in the experimental group, pre-test vs. post-test.
Source: compiled by the authors (2020).

Illustration 3 reveals the progress between the implementation of the pre-test and post-test instruments after the intervention of the PBL strategy had concluded; the strategy led to more awareness in the work pertaining to the development of competences, in particular of scientific competences for natural sciences. Based on what was proposed, the control and experimental groups' progress following the intervention with the PBL strategy can be acknowledged, as seen in Illustration 4.

Accordingly, PBL allowed students to undertake work that was guided, organized and pertinent, since the topic of the respiratory system was addressed with a contextualized approach in which students became active subjects of their training and academic progress.



Correct responses in the post-test, control vs experimental group.
Source: compiled by the authors (2020).

Finally, the pre-test and post-test analysis of the control group revealed that there were no changes in the process related to scientific competences, which is exemplified in Illustration 5.

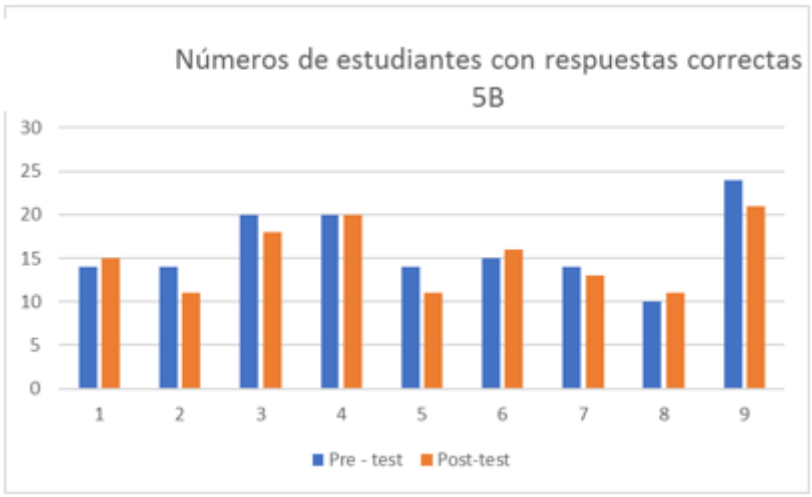


Illustration 5.
Correct responses in the pre and post-test, control group.
Source: compiled by the authors (2020).

DISCUSSION AND CONCLUSIONS

Applying pre-tests and post-tests provides relevant information to intervene a social group and to adequately analyze it, in other words, the tests allow to recognize and identify students' needs and level when addressing the topic suggested alongside the implementation of the PBL.

PBL provides greater problem-solving possibilities to students, helps them use knowledge in context and develop autodidactic skills because the methodology aims to connect context and proposed problems, and to turn students into active subjects of the training process.

PBL can be used as a strategy to transform traditional education and to assign a more active role to students within their own training process. PBL is an innovative process that goes beyond master class teaching, in it, students face real problems that generate solutions based on their prior knowledge.

It is essential to contextualize classes with students' realities, not just to achieve meaningful learning, but to awaken their interest and curiosity. This factor is seminal for students to make progress in their training process because encouragement is an intrinsic part of learning and teaching, if students are motivated then they will be able to articulate their ideas with contextualized learning.

Following this strategy's eight steps enables strengthening students' scientific competences, moreover, it may help develop other skills, such as interpretation, proposition and metacognitive skills and an array of others that build the core of the curriculum.

In order to validate and acknowledge the efficiency of the PBL methodology in developing scientific competences, it is important to implement the proposal in the control group, with the objective of giving the opportunity to both groups to boost scientific competences and make advancements in that process in the fifth grade, with their eyes set on their upcoming academic process in high school.

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