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To cite this article: R Prada Nuñez *et al* 2022 *J. Phys.: Conf. Ser.* **2159** 012017

Journal of Physics: Conference Series **2159** (2022) 012017 doi:10.1088/1742-6596/2159/1/012017

Training action for physics teachers: an application of problem-based learning

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Abstract. The teaching of problem-based learning is a didactic approach that requires a radical change in the role of the physics teacher because it is focused on learning, research, and reflection that students follow to reach a solution to a problem situation as a starting point for the acquisition and integration of knowledge in science. The results of a training action for physics teachers on the implementation, their perceptions, and perspectives on the feasibility of the problem-based Learning approach are presented. The study is quasi-experimental in nature with pre-test and post-test in the study variables. The results suggest that the teachers' perceptions are positive, which is why they consider that its implementation in teaching is viable, however, they need more elements that facilitate their execution in the classroom, such as understanding the theoretical foundations and their pedagogical use successful in the classroom. It is concluded that, for the physics teaching process, problem-based learning is an innovation because it allows the student to learn actively, in which inquiry is relevant for the development of skills and appropriation of knowledge, which in the framework of natural sciences leads to the reconstruction of the scientific method.

1. Introduction

Teachers are a fundamental part of the educational process, so they must acquire pedagogical skills that allow the implementation of methodological strategies to innovate their pedagogical practice, so their training is key to leaving behind the use of conventional practices that do not favor the learning of students taking subjects such as physics. That is why it is necessary for teachers to be constantly qualified, to improve their skills, in accordance with educational innovation, to respond to the transformation of traditional models to active methodologies in which the student assumes a more leading role in their learning, which is necessary for science education to be relevant.

This is evidenced in the change in attitude of the students as they become empowered with their knowledge [1]; as the teacher training process does not correspond to the needs of its environment, it is becoming an educational problem. This is one of the problems of this study, whose research object is the application of problem-based learning (PBL), as an innovative strategy, so that natural sciences teachers are trained, take it to their pedagogical practice and motivate students to be architects of their own knowledge.

The PBL is student-centered learning, in which problems are solved under the teacher's guidance to integrate new knowledge and develop strategies and skills within the research field [2]; it is since the student possesses knowledge and skills to construct solutions to socio-scientific questions of real everyday problem situations, which are interdisciplinary in nature [3], motivating and intriguing, to pose questions to the student, which favors work in team and interpersonal relationships in the student in order to solve problems, which benefits the teaching process [4]. In other words, it is part of the student's life experience, and with this they are motivated to participate in their own knowledge [5].

From Pérez's perspective [6], the teaching of PBL can be organized in the following phases: from the presentation of the problematic context (selected or constructed by the teacher), students, preferably in groups, generate hypotheses for solution and they construct research questions, through brainstorming. They then go on to search for information to solve each question. Finally, there is a synthesis of the learning carried out that is accompanied by the evaluation of the process, by the students and the teacher.

This strategy changes the roles of both educational actors, as pointed out by Navarro, *et al.* [7], who ensure that the teacher stops being a transmitter and becomes a counsellor, while the student assumes responsibility for their learning, identifying what they already know, what they need to know and do to solve this problem, in a way critical and reflective and thus integrate previous knowledge with new, to achieve meaningful learning [8].

Because it is a novel methodology in the field of science education, and because it requires changes in the way of acting in the classroom, some authors have studied the attitudes of students and teachers to this methodology. Regarding the students' attitudes, the study by Pérez [9], with basic education students, who studied the natural sciences area, showed that they liked the PBL approach, with special emphasis on knowing-knowing and knowing-do, being necessary to work more knowledge-being.

Labra, *et al.* [10] conducted a study with teachers in training under this same approach, where it was determined that the approach is motivating since it allows participation in classes and teamwork. Regarding teachers, it was found that the introduction of PBL was positively valued as a method to acquire scientific competence and various transversal competencies [11]. However, another study found that the level of knowledge of teachers about PBL is almost nil, as well as its use in teaching, highlighting the use of a constructivist methodology [12].

Therefore, teachers and students seem to react well to its introduction to science education; however, the novelty in its use and the challenges of its implementation pose theoretical and practical training actions for teachers that, at the same time, allow them to understand the theoretical foundations and understand how it can be implemented successfully in the classroom. Therefore, it was proposed as an objective to determine the impact of a training action on natural sciences teachers and their perceptions on PBL-oriented teaching, as well as their feasibility perspectives.

2. Method

The type of study is analytic longitudinal (quasi-experimental) with a before/after (or pre-post) design without a control group; this type of design is based on the measurement and comparison of the response variable before and after the subject's exposure to the experimental intervention. They allow the researcher to manipulate the exposure, but do not include a comparison group, each subject acts as his or her own control.

To achieve the objective of the study, a training action was developed which lasted 25 hours and was aimed at natural sciences teachers; this action was implemented in a primary and secondary school that expressed interest in training its teachers; a group of 21 science teachers was formed who voluntarily decided to participate in the training action and agreed to collaborate in the study; of the 21 teachers, 6 have a degree in biology and chemistry, 4 have a degree in mathematics and physics, 11 have a degree in natural sciences. In terms of academic training, all of them have postgraduate studies, of which 14 teachers have a master's degree and 7 have a specialization. 10 of these teachers are over 30 years old, 12 are women and 10 have more than 15 years of service.

The objectives of the training action were: to reflect on the characteristics and the role that problems have played in science teaching and learning; to analyze current perspectives for the use of problems in science teaching and learning; to characterize problem-oriented teaching and learning as well as the roles of teachers and students; to critically analyze problem-oriented teaching materials and experiences; to develop didactic material for implementation in science teaching and learning assessment.

Before and after the action, data were collected through a questionnaire on the teachers' perceptions of PBL and their perspective on its feasibility; the collected data were analyzed to find out the possible evolution of the group of teachers in the topics covered.

3. Results and discussion

From the design, implementation, and evaluation of the training action for teachers, it was evidenced that the PBL is an approach that favors their teacher training process where their teaching skills are improved, strengthening the teacher-student relationship based on a more dynamic interaction, where the particularities of the students are recognized. The teachers' responses are presented below according to the responses to the questionnaire on teachers' perceptions of PBL, as well as their perspective of viability (see Table 1).

According to Table 1, it was found that teachers' perceptions became more adequate as the number of complete responses increased and the number of incomplete responses decreased. The latter were characterized by the omission of one of the following ideas required in the complete responses: the problem is the starting point for learning; the student is responsible for learning; the teacher is a facilitating and guiding agent of the whole process. In addition, there was a relevant decrease in relation to the omission of the teacher's role, since before the training, it was omitted by 14 teachers, while after the training only 5 did not mention this aspect. Furthermore, there is no accentuation of the decrease in the responses of teachers who do not know or do not answer, from before with 33.3% to after the training whose percentage decreased slightly to 23.8%.

Table 1. Teachers' perceptions of PBL and their perspective on its feasibility.

Perceptions	Before	After
Complete	0	5
Incomplete	14	11
Don't know / no answer	7	5
Feasibility of the approach	**Before**	**After**
It is feasible	5	0
Long program duration	4	6
Lack of time	4	4
Lack of resources	4	4
Follow-up needs	4	1
Delay of the process	0	1
Limited applicability	0	4
Lack of training for students	0	1
Student reaction	**Before**	**After**
Positive	8	8
Negative	2	2
Negative to positive	5	2
Positive to negative	4	2
Depends on students	2	5
Don't know	0	2

The teachers' perspectives on the feasibility of implementing PBL-oriented teaching before and after the training are presented in Table 1. It was evident that, before the training, 5 teachers thought it was feasible to implement this type of approach. However, after the training, they considered that there are some constraints that make its implementation difficult. This change may be because they are more aware of the requirements needed to implement it.

Therefore, all teachers considered that it is feasible to implement the approach, but that some limitations must be considered, the most recurrent being those related to the length of the program (6 teachers), lack of time (4 teachers), scarce resources (4 teachers) and those who consider that PBL is applicable only in some contents (4 teachers).

On the other hand, on the possible reactions of students to PBL, according to teachers, before and after the training, as shown in Table 1, after the training action, the number of teachers who anticipated positive reactions remained the same 38. On the other hand, the number of teachers who consider that students' reactions will change (from positive to negative or vice versa) decreased. as a result, the number of teachers who reported that these reactions will depend on the students increased.

Regarding the implementation of the approach to teaching physics after the training, all teachers stated that they would implement it and the reasons why they would implement it are summarized in Table 2. According to Table 2, it was found that these focus on methodological aspects, with 21.9% of teachers considering PBL to be an approach that allows for greater success in learning. In addition, 14.6% consider that it is motivating and that it has an added value for the student by giving him/her an active role (12.2% of opinions). It is noteworthy that 4.9% of teachers stated that they would like to implement the approach to test their teaching competences.

Table 2. Reasons to implement the approach.

Reason	After
Makes learning more successful	9
Makes learning more active	3
Is motivating	6
Assigns an active role to the learner	5
Develops learner autonomy	4
Fosters learner curiosity	2
Builds critical learners	2
Develops interpersonal relationships	2
Is a new educational approach	2
Test your competences as a teacher	4
Experience a new strategy	2
Total	41

* Teachers could mark more than one answer.

How teachers planned to implement the problem-oriented approach to learning was also investigated and is visualized in Table 3. It was found that teachers refer to the four phases addressed during the training action [6]: 39.1% mentioned the selection or construction of the problematic context, 26.1% refer to the formulation and selection of problems, while 19.6% refer to problem solving, and the remaining 15.2% recall the synthesis of what was learned and the evaluation of the process.

Table 3. Perspectives on steps in the implementation of the approach.

Stage	Activities	After
Problem context	Scope of intervention Choice/construction of context Quality criteria of the scenario	18
Formulation and selection of problems/questions	Formulation of questions by learners Analysis/selection of questions Classification of questions	12
Problem solving	Problem solving Preparation of the final product	9
Synthesis and evaluation of the process	Synthesis of the process Process evaluation	7

* Teachers could mark more than one answer.

Finally, teachers were asked about possible limitations that may arise in the implementation of the PBL approach, whose opinions are organized by means of Table 4. Table 4 shows that in the opinion of the teachers surveyed, 65% of the limitations for the implementation of the PBL approach are mainly concentrated on curricular aspects, followed by those of the teacher.

Regarding the concept of PBL, for teachers, it is a didactic strategy for the teaching and learning process, which is based on using problems [9] for the acquisition of new knowledge through teamwork by students, as it generates in them cooperative work skills and the assignment of tasks to each of the team members [13].

In addition, teachers consider that PBL is a contribution to their professional teacher training as it improves their professional performance, from an integrative and interdisciplinary approach [14-17], which changes their role to a facilitator of knowledge, so they must have the necessary knowledge to be able to apply it, as without this they will hardly be able to exercise this methodology in an adequate and optimal way; in addition, PBL helps the formation of a research culture in teachers [18].

Regarding whether the student understands the information better with the implementation of the PBL approach, for example compared to traditional methods, the results coincide with [19], who mention that this approach tries to proceed having a proximity to real life compared to traditional methods, because these are static and do not mention anything of the reality of society.

In the opinion of the teacher, for the students who take physics, the classes are more interesting with this methodology, as it is not the same to be an active actor of knowledge as a passive one in its construction [15], which allows them to develop competences such as inquiring through scientific methods to construct knowledge and explain the physical world [20]. It is therefore recommended that adjustments be made to curricula [21], especially in subjects such as physics. This shows that the use of innovative pedagogical approaches such as PBL should be of great interest to the teacher to support the teaching-learning process of physics, since in students the gain of active learning is enhanced [22], and they allow the integration of scientific knowledge [23].

Table 4. Possible limitations in the implementation of the approach.

Axis	Limitations	After
Teachers	Insufficient training Lack of experience in using the approach Resistance to use More interdisciplinary work	12
Students	Insufficient training	9
Time	Delay of the process Lack of time	5
Curriculum	Long program duration Nature of curriculum Rules of school functioning Class dynamics External assessment	14

* Teachers could mark more than one answer.

4. Conclusion

The results suggest that the teachers' perceptions after receiving the formative action about problem-based learning changed positively and they considered it viable, and that, in general, the students would react well to it, despite having identified some possible limitations to their learning. implementation. However, due to the novelty in the teaching of physics and the change of roles that this approach imposes, it seems necessary to continue training teachers in its implementation in the classroom.

Therefore, it is concluded that, for the physics teaching process, problem-based learning is an innovation because it allows the student to learn actively, in which inquiry is relevant for the development of skills and appropriation of knowledge, focused on solving problems in their context, which in the framework of natural sciences leads to the reconstruction of the scientific method. Finally, as future studies, on the one hand, it is recommended to investigate the use of this approach in the initial training of teachers and on the other to carry out a comparative study between PBL and traditional teaching to validate the practical application of this approach using a scenario real learning.

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