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Parque Científico-Tecnológico, Edificio Polivalente II, C/ Practicante Ignacio Rodríguez, s/n
Campus Universitario de Tafira, 35017
Las Palmas de Gran Canaria, Spain

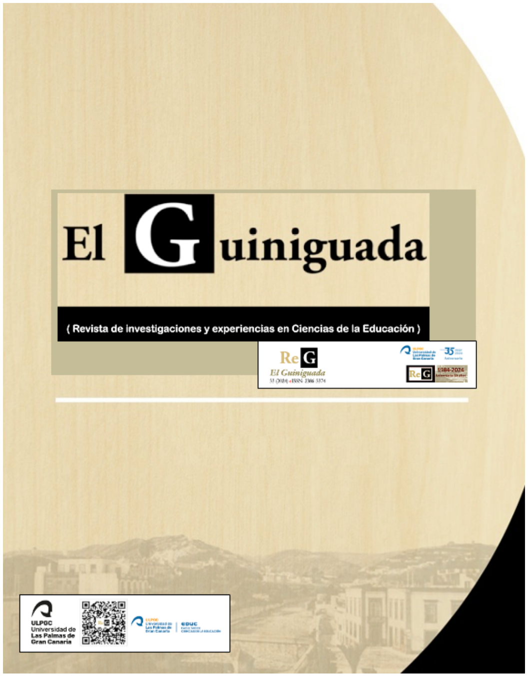
El Guiniguada

(Revista de investigaciones y experiencias en Ciencias de la Educación)

eISSN: 2386-3374

10.20420/ElGuiniguada.2013.333 (doi general de la revista)

Journal information, indexing and abstracting details, archives, and instructions for submissions:
http://ojsspdc.ulpgc.es/ojs/index.php/ElGuiniguada/index



Discovering the fauna and flora of our campus: an example of PBL in teacher training

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DOI (en Sumario/Título, en WEB de la Revista)
Recibido el 03/12/2023
Aceptado el 12/05/2024

El Guiniguada, 33 (2024), pp. 01-12
Print ISSN: 0213-0610 – eISSN: 2386-3374

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RESUMEN
La desafección que muestran el alumnado de magisterio hacia el aprendizaje de las ciencias naturales condiciona su rendimiento y, por ende, sus futuras habilidades docentes. Trabajando en un contexto STEAM, esta propuesta pretende acercar el Aprendizaje Basado en Proyectos (ABP) a la docencia del Grado en Educación Primaria, proporcionando nuevas habilidades y herramientas por medio de una experiencia práctica sobre flora y fauna. A través de un cuestionario de motivación específicamente diseñado, se analiza el grado de satisfacción del grupo participante con esta metodología y sus expectativas respecto a su aplicación en el contexto de la etapa de Educación Primaria. Los resultados muestran una valoración positiva de la inclusión del ABP en su desarrollo formativo, poniendo de relieve la importancia de utilizar metodologías activas e innovadoras en el aula.

PALABRAS CLAVE
ABP, EDUCACIÓN PRIMARIA, MOTIVACIÓN, STEAM, INNOVACIÓN DOCENTE

ABSTRACT
Disaffection shown by trainee teachers towards the learning of natural sciences restricts their performance and, therefore, their future teaching skills. Working in a STEAM context, this proposal aims to bring Project Based Learning closer to Primary Education students, providing them with new skills and tools by accomplishing an applied experience about flora and fauna. By means of a motivation questionnaire specifically designed, the degree of satisfaction of the participants with this methodology and their expectations regarding its application in the context of the Primary Education stage are analyzed. Results show that students value positively the inclusion of PBL in their educational development, highlighting the importance of using active and innovative methodologies in the classroom.

KEYWORDS
PBL, PRIMARY EDUCATION, MOTIVATION, STEAM, TEACHING INNOVATION

INTRODUCTION

The evolution of teaching practice has led to the appearance of new methodologies that are more active than traditional teaching systems. The integral training of students should be the desirable objective, overcoming obsolete patterns that attribute to them a spectator role. From the constructivist perspective, the learner can and should participate in the learning process; concepts such as discovery and research should be firmly incorporated into academic training (Ortiz, 2015; Serrano and Pons, 2011).

Project-Based Learning (PBL) is now considered a mature and fully established methodology in the Spanish educational scenario (Ausín et al., 2016; Bohórquez and Checa, 2019; Holm, 2011; Greene and Azevedo, 2009; Rekalde and García, 2015; Sáiz, 2018). As a powerful tool for the full development of any university teaching, it is even more necessary in the University Degree in Primary Education (DPE), the subject of this article. To their preparation as teachers, with in-depth knowledge of the curricular content to be taught, and as experts in pedagogy who must generate environments conducive to the learning of their students, we must add their scientific instruction so that they can identify the challenges of their innovative and research work, beyond the simple collection and ordering of data, rules, and principles.

For Garrigós and Valero-García (2012), PBL means that students become involved autonomously, not completely independent of the teacher, but moving through the zone of proximal development advocated by Vygotsy (Margolis, 2020) to face the challenge posed with their personal research and find an appropriate solution. They must solve a problem by first designing the tasks to be carried out, modelling their learning, deciding what research to carry out and, in short, making a series of decisions. It is the backbone of the knowledge acquired theoretically and a practical way of acquiring the competences that will be needed later.

Seeking meaningful learning, this methodology prioritizes association over repetition. Knowledge is assimilated in an orderly, effective, and permanent way, not stored temporarily (Hernández-Ortega et al., 2021). It proposes the possibility of facing learning situations based on real events. When students are outside their usual environment, they will need an additional effort that will be excellent practice for the performance of their professional work in teaching. PBL increases their versatility and responsiveness (Portolés et al., 2023).

The reinforcement of subjects with practical activities is not mere repetition, but an attractive alternative approach that is closer to real life. In the field of natural sciences, this perspective reaches its maximum degree of reality, since it is not possible to approach these disciplines without their practical side: experimentation, laboratory, animal sightings, interpretation of landscapes based on the distribution of tree species, etc.

On the other hand, a serious problem for university students is the deterioration of reading comprehension and writing skills, a direct consequence of the growing addiction to the use of electronic devices (Margolin, 2013; Schank, 2022). In this context, the reduced ability of future generations of teachers to produce grammatically, orthographically, and didactically acceptable texts is no small problem. Furthermore, Desmurget (2019) shows how the indiscriminate, excessive, and uncritical use of social networks as a bibliographical source consolidates unverified knowledge which, through copying and reiteration, ends up becoming unquestionable truths.

For this reason, the design of the PBL proposal pays special attention to the development of Linguistic Communication Competence and the methodologies used to search for information. To this end, the students will be asked to write a report with specific vocabulary and writing style appropriate to the university level; in addition, the reliability of the bibliographical sources consulted will be checked. In this way, both the achievement of the conceptual objectives and the way in which they are expressed will be evaluated.

Francisco Mora, a renowned Spanish expert, highlights the connection between motivation and learning. In his work *Neuroeducation*, he elaborates on how motivation, by activating specific regions of the brain, influences attention and memory: *"Motivation involves emotions that are processed by specific areas of the brain, activating neural networks that favour retention and learning"* (Mora, 2013).

According to studies by Ryan and Deci (2000), intrinsic motivation is essential for fostering engagement and meaningful learning in educational settings. As Reeve (2012) points out, they are instruments that capture intrinsic motivation by allowing students to express their interests and values. Vallerand's (1997) research highlights the importance of understanding motivational factors to improve the quality of teaching and, precisely, motivation questionnaires provide valuable data on students' preferences and needs. Thus, as an essential part of the proposal, a motivation questionnaire has been designed to assess their willingness and interest towards PBL, in order to adapt pedagogical strategies and improve the effectiveness of the method.

OBJECTIVES

The overall objective is to improve learning outcomes and competences in natural sciences within the STEAM domain in the DPE through the application of an active and motivating PBL methodology. The stages to achieve this objective are:

- Design of a project focused as field work in which new didactic materials, both manipulative and digital, must be used.
- Execution of the project by the students, applying transdisciplinary knowledge and procedures typical of STEAM subjects.
- Assesment of its results
- Preparation of a questionnaire of motivation towards PBL, and its application after carrying out the experience.
- Statistical analysis of the answers and drawing of conclusions.

METHODOLOGY

Design of the proposal

This is a practical activity of a transdisciplinary nature in the STEAM field linked to the subject Didactics of Natural Sciences I of the DPE. The students, under the guidance of their teachers, characterized the biodiversity of the university campus, divided into sample plots. In each plot, tree and shrub species were determined (number, location, synergies, and height). Electronic laser distance measuring devices and dichotomous keys supported by mobile applications were used. Knowledge of plant morphology and anatomy, mathematics and geometry were applied. The Digital Teaching Competence was present using specific software for the calculation of the average leaf area; in

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relation to the artistic and graphic competences, detailed maps of the vegetation of the campus were obtained, studying the location of native and non-native species in the gardens, and analyzing their suitability.
Vertebrate animal fauna was sampled by direct observation and study of tracks, traces, and signs, using mobile applications. Indirect techniques were used to determine the presence of species that are difficult to observe, and special emphasis was placed on the presence of invasive species.
For the study of microfauna, soil samples were collected, and, in the laboratory, microfauna were isolated and identified with the help of microscopes and binocular magnifying glasses. Samples were also collected from springs, ponds, and occasional puddles.
During the activities, an interactive notebook was used, designed ad hoc, in which the objectives of each activity, the materials and methods required and the exercises to be carried out were specified. Interactive teaching resources were also used, some of them innovative, such as the Wordwall or Wooclap platforms or the manipulative material associated with virtual reality, Merge Cube.

Motivation questionnaire design
It was drawn up by a multidisciplinary team of teachers from the Didactics of Experimental Sciences area. The 4 initial questions were used to characterize the educational profile prior to accessing the DPE. The rest were 24 closed questions on PBL with predefined response options, which facilitates the quantification and analysis of data using Likert scales from 1 (Very little) to 5 (Very much). The methodological design sought to ensure clarity, relevance, and consistency in data collection.

Participants
The questionnaire was answered by 54 students, 26 women and 28 men in the third year of the DPE, with a major in Physical Education, at the Fuenlabrada campus of the Rey Juan Carlos University (URJC). The average age of the participant group was 21.6 years, and the form was applied after the end of the project.

Data processing
Data collected on ABP were analyzed using MS Excel. Descriptive statistics were applied to obtain central measures (mean, median, standard deviation) and to generate distributions and graphs to help identify relevant trends and patterns (Table 1).

Table 1. Results of the statistical analysis of the responses.

	Interests and Expectations towards PBL							
	P5	P6	P7	P8	P9			
Mean	3,96	4,37	3,94	4,30	3,28			
Median	4,00	4,00	4,00	4,00	3,00			
Mode	4,00	4,00	4,00	5,00	3,00			
Standard dev.	0,82	0,62	0,63	0,72	1,02			
Overall average	3,97							
	Self-efficacy and Confidence							
	P10	P11	P12	P13	P14	P15	P16	P17
Mean	3,96	4,13	3,41	3,52	4,30	3,46	3,58	3,61

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Print ISSN: 0213-0610 – eISSN: 2386-3374

Median	4,00	4,00	3,00	4,00	4,00	3,00	4,00	4,00
Mode	4,00	4,00	3,00	4,00	4,00	3,00	4,00	4,00
Standard dev.	0,89	0,73	1,04	1,04	0,72	0,77	0,80	0,86
Overall average	3,75							
	Impact Perception and Practical Implementation							
	P18	P19	P20	P21	P22	P23	P24	
Mean	4,35	4,07	4,11	4,17	4,04	4,09	4,26	
Median	4,00	4,00	4,00	4,00	4,00	4,00	4,00	
Mode	4,00	4,00	4,00	4,00	4,00	4,00	4,00	
Standard dev.	0,65	0,91	0,64	0,69	0,80	0,68	0,71	
Overall average	4,16							
	Opinions and Future Expectations							
	P25	P26	P27	P28				
Mean	3,89	4,13	3,67	4,00				
Median	4,00	4,00	4,00	4,00				
Mode	4,00	4,00	4,00	4,00				
Standard dev.	0,72	0,58	0,93	0,80				
Overall average	3,92							

RESULTS

PBL Didactic Proposal

Detailed aspects of the phases of the project, the established work sessions, the competences developed in relation to the contents of each session, the evaluation system, and patterns of educational inclusion of students with potential diversities are described below.

Phase 1. Data collection

The campus was divided into 10 sampling plots of approximately 3 hectares, with groups of 8 people assigned to each plot. The plots have landscaped flowerbeds with native and exotic woody plant species. The campus is perimetered by a more naturalized vegetation belt with only Iberian species. Each plot includes a part of the perimeter belt.

Phase 2. Study of the campus flora

The first step was to determine the species of trees and shrubs using the dichotomous key of the free *Arbolapp* application from the Royal Botanical Garden of Madrid, which successively identifies morphological characters until the specimen was determined. In addition, other mobile applications were used, such as *PlantNet* and *Seek*. A photographic portfolio was taken of each species: habit (general appearance), leaves and, if present, flower and fruit.
Dendrometric parameters were obtained for each species. The average height was calculated by applying Thales' theorem; the average volume of the trunk, assimilating it to a cylinder, from the ground to the beginning of the branches, using the diameter at the normal height of the tree (1.30 m); the average leaf area of each species, using the polygon conversion method and the *GeoGebra* software, measuring two leaves of each tree.

Phase 3. Study of the campus fauna

This was carried out by determining the vertebrate species present in each plot using free applications. Birds were identified using the mobile applications *SEOBirdLife* and *BirdNet*. Complementarily, other vertebrate groups were determined using applications such as Seek. Where feasible, a photographic portfolio of species was made.

For soil microarthropods, the practice is divided into three stages: a) Collection, taking four soil samples of approximately half a kilogram; b) Extraction of the microarthropods in the laboratory; c) Characterization with the aid of microscopes or binocular magnifying glasses.

Phase 4. Data integration

Once the data have been collected and analyzed, a report (minimum length 10 pages) must be elaborated according to the format of the Final Degree Project of the URJC with the intention that they begin to familiarize themselves with this subject.

Phase 5. Presentation of the results

All the works were presented to the rest of the groups, who were previously prepared to assume the role of an assessment panel. We consider that this last phase of the project should be followed and evaluated with special attention.

Characterization of the project

The field and laboratory work of the project was carried out in the first term of the academic year 2023/24. In relation to the attention to diversity, we worked with the hypothesis of possible dysfunctions (Attention Deficit, Hyperactivity, Asperger's Syndrome, Epilepsy) not diagnosed or diagnosed but not reported. Inclusive strategies similar to those used in the case of diagnosed and reported disorders were adopted (Table 2).

For example, commissioning patients with an autistic spectrum disorder to provide graphic documentation of each phase may help their integration into the working group. Care should be taken to ensure that no member is isolated from the group, to foster cohesion and to encourage mutual support and companionship. When working in the classroom, key words should be written on the board, digital or not, or projected on the screen, highlighted with underlining, color, special fonts or in some other way. If the teacher cannot closely follow the integration of the data because of autonomous work, interpersonal cooperation should be sought. An explicit form of inclusion of learners with special educational needs is to allow them to take an active part in the presentation phase of the work.

Table 2. Proyect characterization

Phase	***Sessions***	***Chronogram***	***Competencies***	***Assesment***	***Diversity***
Sampling	5 x 1 h	13, 15, 20, 22, 27 SEP 10:00-11:00 Campus	STEM CD CPSAA	Rubric	Graphic Documentation
Flora study	3 x 1 h	5, 7, 11 OCT 12:00-13:00 STEM Classroom/Lab	STEM CD	Rubric	Palabras clave Participation
Wildlife study	3 x 1 h	13, 18, 20 OCT 12:00-13:00 Aula/Laboratorio	STEM CD	Rubric	Keywords Participation

Integration	10 x 1 h	13 SEP – 20 OCT Autonomous work	CCL STEM	Rubric	Cooperation
Exposition	1 x 10 min	25, 27 OCT 11:00-13:00 Classroom	CCL STEM	Rubric	Exposition

Motivation questionnaires
The first part of the questionnaires (Q1 to Q4) provided information on the academic profile of each participant. The way of access to the degree is relevant. Figure 1 shows that the preferred route was the EvAU (68.2%). The largest group (44.44%) studied Social Sciences Baccalaureate, while 25.93% studied TAFAD (Higher Technician in Physical and Sports Activities, Vocational Training). Only 16.67% came from scientific-technological Baccalaureate courses and only 7.41% from the Humanities Baccalaureate.

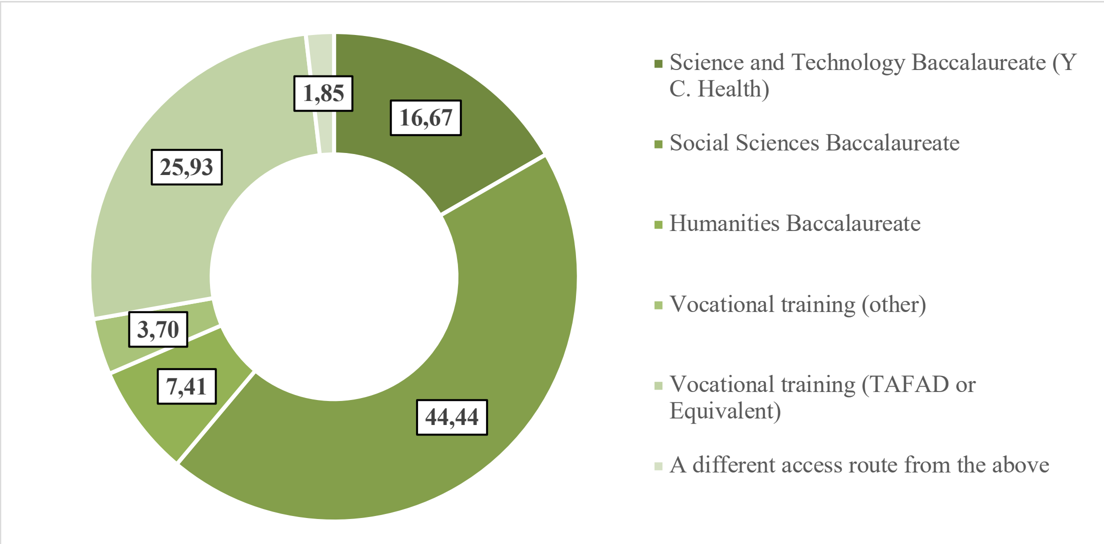

Figure 1. Access profile of DPE student respondents (percentages).

This 24.07% indicated that they had previous experience in PBL applied to natural sciences, but prior to entering university. However, no correlation was found between the educational pathway of access to the DPE and their PBL experience in science.
As for the specific questions on motivation for the PBL method (Q5 to Q28), the questionnaire is structured in four main dimensions:

- Opinions and Expectations regarding PBL.
- Perception of the Impact and Practical Application of PBL.
- Self-efficacy and Confidence.
- Interests and Expectations towards PBL.

The dimensions and overall averages are shown in Figure 2, where a good perception of the PBL methodology can be seen, with average scores above 3.70.

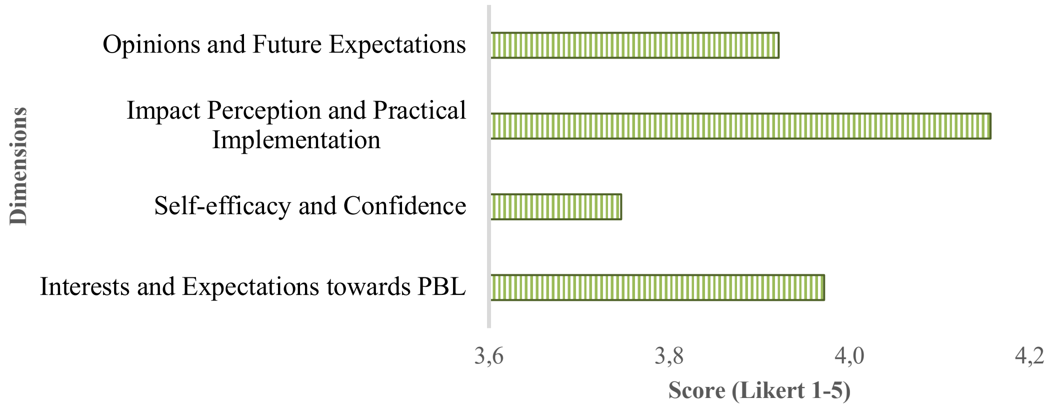

Figure 2. Dimensions of the motivation questionnaire and mean values obtained.

Regarding the individual analysis of each dimension, the responses coincided in showing, in the first place, a very favorable perception of the impact of PBL on the teaching-learning processes (4.16 points). There was a general belief that PBL can effectively influence the understanding of environmental problems, and that the application of this methodology stimulates very positive aspects for personal and academic development (4.07 points).

Secondly, the high expectations generated by this methodology were rated with 3.97 points. In this sense, PBL is considered to improve learning in the field of natural sciences (4.37 points, the best rating obtained).

Regarding self-efficacy and confidence in applying this methodology, the results gave a score of 3.75 points, somewhat lower than the rest, but they considered that they were well disposed to put PBL into practice. However, the answers to some questions show that some participants did not feel they had fully achieved the necessary skills to lead the design of a project of this type (scores around 3.5).

Another interesting question is the willingness to devote additional time outside the classroom to carrying out this type of project. This question obtained an average score of 3.28 points which, although acceptable, was the lowest, showing that the students were not fully motivated to extend their dedication.

The results are characterized globally by means of a box-and-whisker plot (Figure 3). A significant concentration around a median of 4.02 was detected, with half of the responses scored between 3.65 and 4.14. The interquartile range shows that the bottom 25% of the scores range between 3.28 and 3.65, while the top 25% range from 4.14 to 4.37.

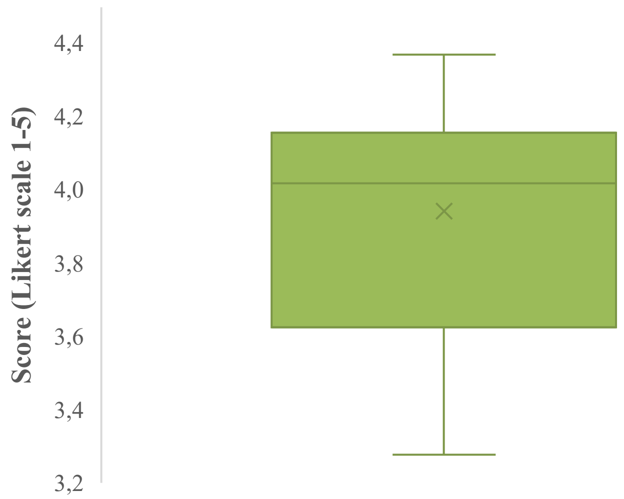

Figure 3. Box and Whiskers diagram for the set of questions analyzed.

The results indicated a higher density of responses towards higher values, pointing to a positive inclination in the perceptions of PBL as an effective methodology. The presence of extreme values at 3.28 and 4.37 suggests the existence of possible outliers, which could influence the overall interpretation of the data.

In summary, most of the scores were concentrated within the interquartile range, although the presence of outliers and possible right skewness in the distribution may impact on the overall understanding of the group's perceptions of motivation towards PBL in the natural sciences.

DISCUSSION AND CONCLUSIONS

After carrying out a PBL experience on flora and fauna present on the URJC Fuenlabrada campus with DPE students and analyzing the answers to a motivation questionnaire, the authors of the study have verified the effectiveness of PBL as a tool for improving teaching-learning processes in the context of teacher training and consider it essential for future teachers to participate in this type of project during their training stage. Those who participated in this project received an extra motivational incentive, as demonstrated when they established which lines of work were most important and which were to be treated as incidental. We agree with Holm (2011) that this is the first step in acquiring new skills that can be exported to the classroom in the future. Intuitively, they designed their research following the stages outlined by Greene and Azevedo (2009) and developed by Sáiz (2018).

The high percentage of success in the determination of species, endorsed by the subsequent statistical study, revealed their interest in this methodology, which, however, they had not had the opportunity to apply at university. Twenty-five per cent had some PBL experience in science during their pre-university education, which reveals that the implementation of the method is still limited at school and almost non-existent at university level.

On the other hand, students show a good predisposition to participate in this type of initiative, which they value as important for their education. In no case did the students rate the dimensions analyzed negatively, although the lowest ratings were observed in the self-perception of their ability to set up this type of project, develop it and present

the results in public. This is probably due to their inexperience, revealing a lack of training that should be considered in the design of future curricula.
Finally, the participating students indicated that PBL seems to them a good strategy to interrelate different fields and disciplines, which refers to STEAM education which, combined with PBL methodology, is a new way of teaching that promotes study in open educational contexts where different subjects interact transdisciplinarily.
In conclusion, this study indicates that PBL for science in STEAM is an effective means of developing the teaching-learning process of DPE students, significantly improving their motivation. Therefore, this didactic approach should be recurrent during the training of future teachers so that they acquire skills and develop adequate capacities to face their future teaching.

Author contributions:
Pablo Melón Jiménez: Conceptualization, Methodology, Software, Formal analysis, Writing-original draft, Supervision, Project Management.
Miguel Portolés Reboul: Conceptualization, Methodology, Software, Formal analysis, Writing-original draft, Supervision, Project Management.
Jesús María Arsuaga Ferreras: Conceptualization, Resources, Writing-Review & Editing, Visualization, Acquisition of funds.
Arcadio Sotto Díaz: Conceptualization, Validation, Data Curation, Visualization, Fund Acquisition.

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