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Biotechnology project-based learning encourages learning and mathematics application

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Project-based learning (PBL) is a promising approach to enhance mathematics learning concepts in higher education. Here, teachers provide guidance and support to PBL implementation. The objective of this study was to develop PBL-based biotechnological projects as a strategy for mathematics learning. The methodology design was applied to 111 university students from Biochemical, Chemical Engineering and Business Administration careers. Knowledge, skills, perceptions, and engagement were measured through questionnaires, workshops, rubrics, and survey instruments. As a result, the paired comparison between tests, questionnaires and project shows significant differences ($p < 0.001$) between the experimental group and the control group. It is concluded that the teaching of mathematics should be oriented to the development of competencies, abilities, and skills that allow students to generate real solutions and broaden their vision of the applicability of their knowledge using new learning strategies.

KEYWORDS

mathematical models, biotechnology, project based learning (PBL), learning, learning mathematics activities

1 Introduction

Science, technology, engineering, and mathematics (STEM) education has become a crucial topic both inside and outside of school (Han et al., 2015). Currently, mathematics learning tends to be oriented towards textbooks, and students can only work on math problems based on what the teacher exemplifies; however, if given different context-based problems, they will have difficulty solving them (Fisher et al., 2020). Likewise, the traditional classroom model does not encourage student's interest in STEM (Sahin, 2009).

The research gap is between what students learn at the university and what they really need in the workplace (Holmes et al., 2015). Higher education institutions have been trying to provide students with both (i) hard skills, such as cognitive knowledge and professional skills (Vogler et al., 2018), and (ii) soft skills, such as problem-solving and teamwork (Lennox and Roos, 2017). However, these skills are difficult to achieve through traditional learning.

One learning that creates an active, collaborative atmosphere, and can increase self-confidence in students is Project-based learning (PBL) (Cruz et al., 2022; Guo et al., 2022; Markula and Aksela, 2022). The PBL method is applied as a teaching model that involves deep study and research on real problems (Asija, 2011). PBL is a model applied in most learning processes, and biomathematics is now considered one of the modern applications of mathematics in an interdisciplinary research field, with numerous applications in biology, biotechnology, and biomedical sciences (Hofmeyr, 2017; Bodine et al., 2020), which allows the modeling of biological processes using mathematical techniques and concepts (Hoppensteadt, 1995; Lombardero, 2014).

For instance, biotechnology applies a set of techniques and tools to modify living organisms to produce new knowledge to develop products and services. Consequently, to promote biotechnology projects, it is important to consider the creation of mathematical models to better understand patterns and phenomena within the world of biology, medicine, ecology, and environmental sciences, according to North Carolina State University (Campbell, 2013).

Several studies have focused on collaborative strategies, such as case studies (Cazes et al., 2006), and simulations (Jiménez et al., 2018), design-based thinking, problem-based learning (PBL) (Zorrilla-Pacheco et al., 2022) based on real problem-solving and knowledge construction in authentic professional contexts (Davidson and Worsham, 1992; Cuseo, 1996; Bature and Atweh, 2019). According to Vivanco-Galván et al. (2018), PBL is an academic strategy that allows the analysis and proposal of new enterprises based on research and innovation. Likewise, to maximize the participation and involvement of students in the content and activities to be developed, collaborative strategies (Chan and Idris, 2017; Oviedo and Zhuma Mera, 2019), which have a positive influence on student learning, were used. Jiménez and Castillo (2018) applied the design thinking methodology as a project-based strategy that allows students to strengthen their mathematical learning.

Nani (2015) proposed a PBL strategy that involves real-life challenges, focusing on real questions or problems with the potential to be applied in real fields. Likewise, Fisher et al. (2020) proposed a descriptive qualitative literature review on the application of PBL in mathematics, where the results indicate that PBL engages students in problem-solving and reasoning activities, given students opportunities to work autonomously to construct their own learning, and produces prototypes, products, or services from the students' work.

Guo et al. (2020) also proposed a literature review of PBL in higher education and concluded that more studies should be conducted to evaluate student learning processes and students' skills and competences. In addition, further experimental research should be conducted to determine the effects of PBL on student learning.

Research suggests learning that emphasizes open-ended problems may be more effective than direct instruction in boosting students' academic achievement (Yeh, 2009; Bartholomew and Strimel, 2018). To successfully implement PBL, we start by training students to answer the open-ended questions typically found in projects of their environment.

To transform this scenario, it is recommended that students engage in authentic professional contexts, where they can actively participate in problem-solving and construct knowledge. To achieve this, a robust learning model is essential—one that enables students to propose solutions for the challenges they encounter using an innovative approach. This model aims to enhance mathematical skills and foster a deeper understanding of the subject matter.

One important field for apply in education is the Biomathematics that finds wide-ranging applications across various fields, including epidemiology, ecology, microbiology, chemical reactions, and intracellular dynamics. In this study, our specific focus lies within the agri-food sector, encompassing wine companies and the cheese industry. Additionally, we explore innovations in crop and seed improvement, such as functional foods and nutraceuticals, as well as their impact on novel food development. Furthermore, we delve into the realm of environmental applications, particularly bioremediation.

1.1 Related work

In this section, we will briefly introduce detailed information about the specific nature of the PBL-based projects developed and implemented, as well as the more recent approaches using PBL, Technologies and ChatGPT.

Lazic et al. (2021) indicate the influence of the PBL model in elementary mathematics education experiments with two groups on a sample ($N = 147$) in order to compare a PBL-based education (experimental) with the usual way of learning mathematics (control). The results determined that there was a statistically significant effect of the interaction between teaching methodology in mathematics education and the mark in mathematics on student performance ($F = 8.040$, $p = 0.000$). Results shown that students from the experimental group have achieved better scores on the test compared to students from the control group.

Cruz et al. (2022) present a review on project-based learning (PBL) in learning math concepts. The basic idea is to do a data analysis focused on math, PBL, and TICs. The potential results suggest that PBL engages students in math learning environments and must be understood as a learning strategy to develop complex and soft mathematics-related skills.

Gningue et al. (2022), also suggest that a positive school climate and teacher leadership have been shown to benefit student achievement. Tashtoush et al. (2023) present a study whose aim is to investigate the impact of Information and Communication Technologies (ICT)-based education on the academic enthusiasm of 61 female students divided into two groups (31 experimental and 30 control) in mathematics. The study utilized the Mathematics Academic Enthusiasm (MAE) questionnaire, which included three subscales: cognitive, behavioral, and emotional. The reliability of the (MAE) questionnaire was evaluated by Cronbach's Alpha coefficient (0.89, 0.92, 0.91, and 0.91) for behavioral, cognitive, emotional, and overall scales, respectively. The study's findings revealed that the ICT-based education method had a more significant impact on students' MAE for the cognitive and behavioral subscales than traditional education methods.

Alneyadi and Wardat (2024) analyze the impact of Chatbot applications on student achievement in Quantum Theory courses. The experimental group (55 participants) received instruction enhanced by ChatGPT, while a control group (57 participants) experienced traditional teaching. The experimental group showed significant improvements in post-test scores for the Knowing, Applying, and Reasoning sub-skills. The overall test score for the experimental group was (15.55, 25.49, 17.51, 68.55) for each respective subscale, while the control group's scores were (10.63, 16.39, 11.73, 61.98). The use of ChatGPT in the experimental group resulted in a notable improvement in the "impact of ChatGPT on student achievement" compared to the control group.

In this sense, the principal aims were (i) to assess the comprehension of mathematical functions, (ii) to develop biotechnology projects PBL-based as a strategy for teaching-learning

TABLE 1 The total score averaging over 10 points to mathematical functions.

Topic	Control group	Score	Experimental group	Score
Mathematical functions	Questionnaire I	4	Questionnaire I	4
	Workshop	2	Workshop	2
	Test	4	Project (PBL)	4
	Total score	10	Total score	10

mathematical functions to university students, and (iii) to know its incidence in the knowledge acquisition, skills, perceptions, and motivation about the PBL application in a real work environment.

2 Materials and methods

2.1 Participants

The project was developed at the Universidad Técnica Particular de Loja (UTPL) with 111 students belonging to Business Administration (Group A), Biochemistry and Pharmacy and Chemical Engineering (Group B) as experimental group; and the control group corresponds to other group of Biochemistry and Pharmacy (Group C). Groups A, B and C were randomized before the start of the project.

The inclusion criteria are specifically targeted university students in their first year, focusing on mathematical functions and their relevance to biotechnology and bioenterprise. The exclusion criteria include academic years, non-mathematical subjects and technical, socio-humanistic, language, and religion careers.

The strategy was applied as a mathematical functions teaching-learning strategy in the second semester of the academic period from October 2018 to February 2019. Each group of analysis has had 37 students.

2.2 Instruments

To achieve our broad goals of equipping students with the ability to apply mathematical functions in their future careers, we employ various instruments in this study. Specifically:

2.2.1 Assessment

We utilize tests, questionnaires, and workshops to evaluate achievement.

To assess the understanding of mathematical functions, several types of instruments were used, such as the level of verbal and mathematical abilities of the students and comprehension assessment tools, such as questionnaires, test and workshops (see Appendix A). The Socrative tool[1] was used to answer the questionnaires and evaluate the teaching-learning process. These instruments were applied to control and experimental groups.

2.2.2 Project-based learning

To develop projects, we implement a project-based learning (PBL) approach.

The project was used to assess the cognitive abilities involved in thinking (e.g., reasoning, teamwork, and problem-solving). To rate the students' project presentation, the quality of the scientific report and prototype a grading rubric with several criteria (see Appendix B) was used. Applied only to experimental groups.

2.2.3 Perceptions and motivation

We assess perceptions and motivation through a survey.

A student survey opinion was used as a PBL project perception assessment instrument with 16 questions of 5-point Likert scale (1: Strongly disagree; to 5: strongly agree), (see Appendix C) applied to experimental groups.

In the table below show details on the scores for each activity in experimental and control group (Table 1).

2.3 Reliability of the instrument

A principal component analysis (PCA) was conducted to examine the factor structure of the survey. The PCA used Varimax rotation and Kaiser normalization. The threshold for the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was 0.6 (Tabachnick and Fidell, 2000). Cronbach's α coefficient values were assessed (Cronbach, 1951) in order to measure the internal reliability of a survey.

2.4 PBL methodology

This methodology was applied to experimental groups (A and B). Our proposal as Math and Biology teachers is to implement the PBL strategy in our lectures, we used the methodology applied by Vivanco-Galván et al. (2018), looking for a better way of teaching and learning mathematical function concepts, trying to facilitate connections between students' learning experiences and their future work environments. To achieve this, we focus on solving real-world biotechnological problems. By engaging with authentic challenges, students can bridge theory and practice, preparing them for their professional journeys.

This methodology includes the mathematical function master classes looking for adapting this knowledge to understand the problem definition, PBL implementation, prototypes, and scientific reporting and project presentation. Finally, the workflow includes the final test (Figure 1).

Here our role as the course teacher was to (i) plan the rules of the project; (ii) form a random work team; (iii) provide direct instructions before starting the project; (iv) monitor student projects during development to ensure that they have enough background knowledge, and (v) learning experience evaluation. The student's role is to propose PBL projects and to present a prototype and scientific report about the research.

1 www.socrative.com

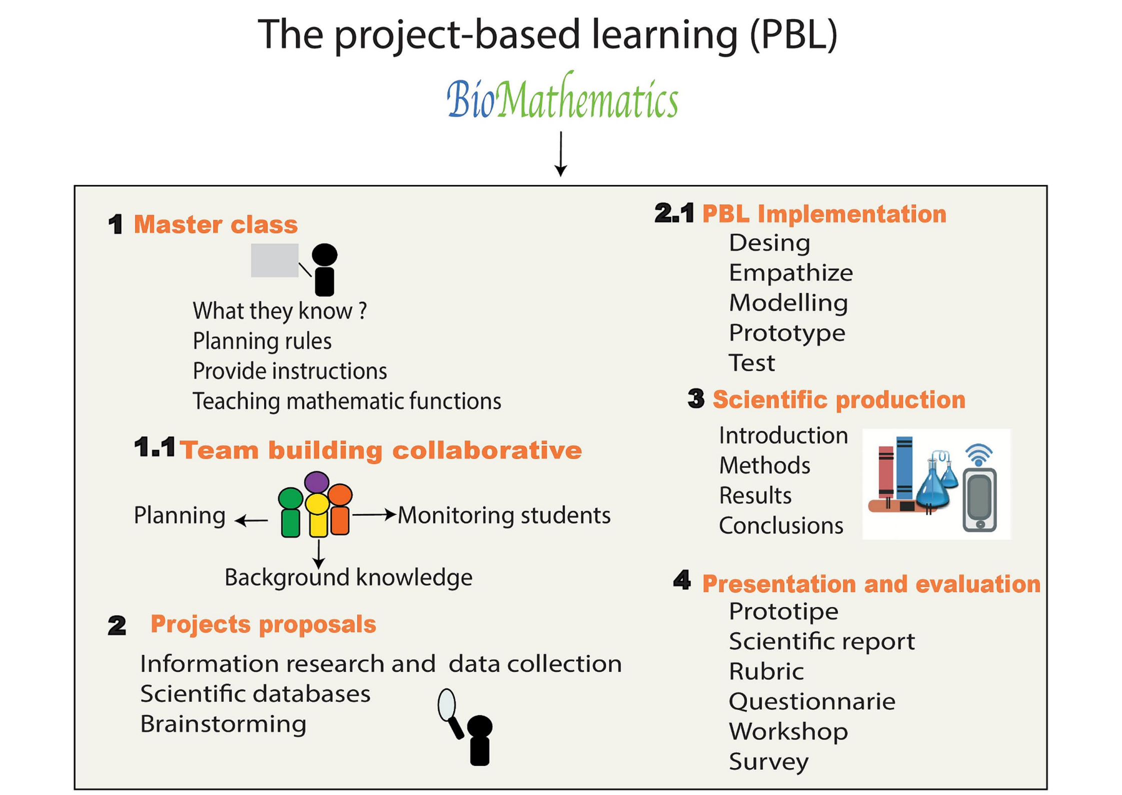

FIGURE 1
Outline of the PBL methodology used as mathematical teaching-learning strategy.

2.4.1 PBL strategy development

The main steps to development the PBL strategy were: (1) master class; (2) project proposals based on innovation, entrepreneurship, and technology topics (3) solution implementation by PBL strategy; (4) prototype and scientific report presentation and (5) results evaluation based on several instruments.

2.4.1.1 Phase 1: master class

According to the teaching plan contents to strengthen students' skills and achieve meaningful learning, the teacher explains the mathematical function concepts with emphasis on the development of practical exercises and workshops on polynomial, rational, exponential, and logarithmic functions. In addition, during the class, the teacher gives the rules of the project, conforms to random work teams, and provides direct instruction before starting a project.

This instruction can range from a short explanation of the quantitative and qualitative experimental design to strengthening scientific knowledge (open-ended questions, problem selection, planning, solution search, prototype design, and evaluation) to reinforcing mathematical topics about the functions describe above.

2.4.1.2 Phase 2: project proposals based on innovation, entrepreneurship, and technology topics

The proposed solutions focused on biotechnology contributions to the sustainable development goals (SDGs), most of which were related to health and well-being, underwater life and terrestrial ecosystems, climate action, affordable and clean energy, and quality education.

2.4.1.3 Phase 3: solution implementation by PBL strategy

The PBL projects were developed through the application of mathematical models, involving especially exponential and logarithmic functions to model bacterial population behavior, growth or decay of a radioactive substance, acidity or pH level of a substance, depreciation of equipment, profitability of a company, and capitalized interest among other biological and administrative applications implemented within the execution of the projects.

2.4.1.4 Phase 4: prototype and scientific report presentation

The evaluation of the projects was carried out by a committee of experts conformed by UTPL teachers-researchers, who used a rubric as an evaluation instrument (Appendix B1) to choose the topics more appropriate to the real needs of different categories. In addition, the scientific report, final presentation, and prototype of the project were considered in the rubric.

2.4.1.5 Phase 5: evaluation of results

Finally, as cognitive skill evaluation the Miller Pyramide (Miller, 1990) was adopted, and Bloom's Taxonomy (Wu et al., 2013) to evaluate the mathematical knowledge.

Students' competencies were evaluated based on the four levels established by George Miller's Pyramid (Miller, 1990). Starting from an initial level (*knows*) to a higher level (*Does*). The initial level was evaluated using workshops, questionnaires, and tests. A higher level was evaluated through the implementation of projects, resulting in prototypes or products (Bueno and Fernández, 2016). Throughout this phase, the student is in the process of learning, so that he/she is acquiring knowledge and increasing his/her formative quality and pre-professional training.

2.5 Data analysis

Statistical analysis was performed using the software R version 4.1 (R Core Team, 2021). The nonparametric Kruskal-Wallis analysis was carried out to test the statistical significance between the experimental and control groups obtained from the questionnaire, workshop, project and final score, followed by the Mann–Whitney test. The descriptive analysis data were expressed as mean ± standard deviation (SD), standard error (SE). The survey was analyzed using principal components analysis (PCA).

3 Results

A total of 111 students participated in the project, 74 students in PBL process from Biochemistry, Chemical Engineering and Business Administration degrees, as the experimental groups and another Biochemistry class as the control group with 37 students. The most relevant results that characterize the PBL strategy and its application in learning mathematical functions are presented below.

In our study, the mean final scores present difference between experimental group (A and B) with an average score of 8.9/10 and 8.82/10 respectively, and the control group I with an average score of 6.66/10 (Table 2).

The results show that Kruskal-Wallis test revealed significant differences in the trueness values between the 3 groups (A-B-C) ($p < 0.001$) for each variable analyzed (Figure 2).

To determine the differences between groups we applied pairwise comparison tests showing significant differences ($p < 0.001$) between the experimental group (A and B) and the control group (C). The variable that showed significant differences ($p < 0.001$) between experimental and control group were Project/test, questionnaire, total score of mathematical functions and workshop (Table 3).

The *p*-values of groups A and B correspond to PBL project, while the p value of C group correspond to the test. The table above show significant differences ($p < 0.001$) between the experimental group and the control group.

Thus, using PBL as mathematical function teaching-learning strategy through the application of workshops based on scientific cases, questionnaires, and projects, it was possible to increase academic performance in the experimental group. The application of the project indicated significant statistical differences (Figure 2) between the experimental group and the control group giving rise to scenarios in which students generate solutions to different problems within their professional environment, increasing their motivation for the study of mathematics.

TABLE 2 Descriptive statistical analysis between experimental and control groups, over each activity.

	Group	Mean	SE	SD
Workshop	A	2.00	0.00	0.00
	B	2.00	0.00	0.00
	C	1.81	0.05	0.36
Questionnarie	A	3.35	0.11	0.71
	B	3.14	0.10	0.62
	C	2.54	0.13	0.79
Project/Test	A	3.55	0.05	0.36
	B	3.68	0.05	0.32
	C	2.31	0.10	0.62
Total score mathematical functions	A	8.90	0.13	0.82
	B	8.82	0.11	0.69
	C	6.66	0.16	0.99

The overall score includes the score of workshops, questionnaire, project to experimental groups (A and B), and workshops, questionnaire and test for control group (C) over a total of 10 points. (A: Business Administration; B: Biochemistry and Pharmacy, Chemical Engineering and C: Biochemistry and Pharmacy). The samples size for each group was 37.

3.1 Projects proposed by students

The proposals on bioentrepreneurship projects were divided into categories and subcategories as shown in Appendix D.

A mathematical model is an approach to reality, for this, the students modeled different scenarios, for example, bacterial growth, radioactive decay of a chemical substance, depreciation of the value of equipment, acidity level of a substance and concentration of hydrogen ions, all of them applied to a mathematical language. Each of the models shows different equations and mathematical functions to predict these processes (Table 4).

Thus, according to the total score obtained from the evaluation rubric scale (9–10 Excellent, 7–8 Good, 5–6 Fair, 4–5 Poor, 1–3 Very poor) the projects order which achieved higher scores under the concept of clarity, rationale, and internal feasibility of the proposal, considered relevant and feasible for its development at the local level are as shown in Appendix E.

3.2 Survey Cronbach's analysis

The opinion survey was applied through Google Forms to identify students' opinions about the PBL methodology applied in the classroom. Cronbach's analysis of the instrument resulted in a coefficient of 0.96; thus, the instrument was considered highly reliable.

The summary survey item results showed that the majority agreed that they obtained significant learning during the application of the PBL strategy, since the 53.5% is in agreement that learned to apply functions as mathematical models for the project development; 48.8% indicated that they learned how to plan a research project and write a scientific report based on the results obtained; 51.2% agreed that the development of the project helps there to understand the applicability of mathematics in their careers. In general, 53.5% say that the PBL strategy had a positive impact on their academic training.

4 Discussion

PBL has been shown to boost academic scores in both experimental and control groups. Additionally, it enhances skills and

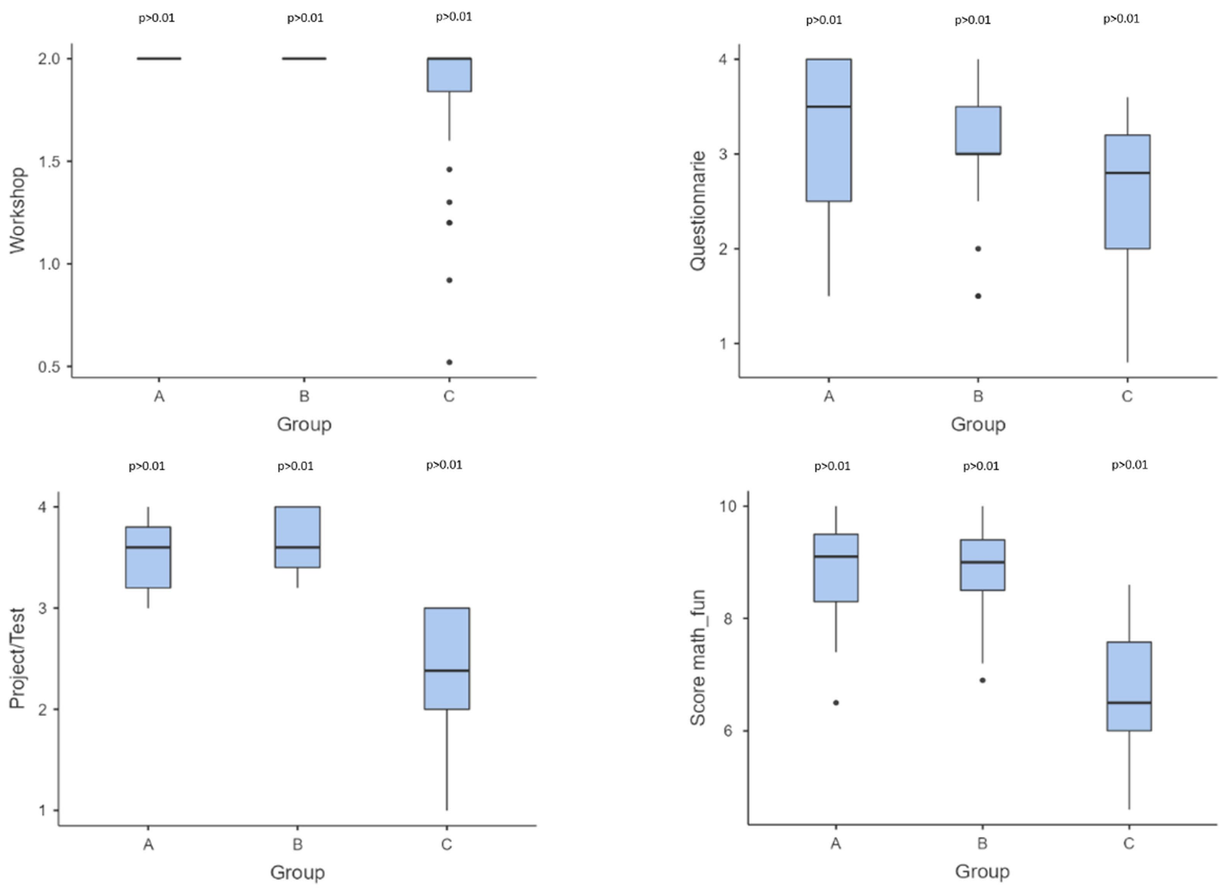

FIGURE 2
Boxplot showing the mean values of experimental and control groups for each variable analyzed. The *y* axis values correspond to the value of each activity. Questionnaire I (4 points), Workshop (2 points), and Test (4 points) in the control group, while in experimental groups we evaluate the Project (4 points) in replacement of the test.

enriches learning experiences by emphasizing the resolution of real-world problems.

The achievement gains, beyond attitude changes, PBL positively impacts student achievement. By applying math to real-world scenarios, students deepen their understanding and retain knowledge. PBL fosters critical thinking, communication, and teamwork—essential skills for success in any field. As a result, student performance improves, and they achieve better outcomes in assessments (Gay, 2022). In a study by Chapman et al. (2011) and Bender (2012) it were noted that the application of Project-Based Learning (PBL) leads to an increase in academic subject-passing scores. Our study reveals that the mean final scores for assessment indicator did not significantly differ between experimental groups A and B. Both groups achieved an average score of 8.9/10 and 8.82/10, respectively. However, a significant difference exists between the experimental and control groups. Specifically, the average score for mathematical functions in the control group was 6.66/10 (as shown in Table 2). Notably, paired comparison tests (Table 2) demonstrate significant differences ($p < 0.001$) for the project between the experimental group (A and B) and the control group (C) across all analyzed variables. This interpretation of the results should be approached with caution due to the limited number of samples. It represents a sample applied at Universidad Técnica Particular de Loja specifically for university careers related to biotechnology and bioenterprise, excluding technical, socio-humanistic, language, and religion careers.

TABLE 3 **Pairwise comparisons of variable Project/Test between experimental and control group.**

		W	*p*
A	B	2.42	0.202
A	C	−10.08	< 0.001
B	C	−10.56	< 0.001

Globally, there has been an increased need to introduce advanced statistical-mathematical models and tools in research (Rodríguez and Bermúdez, 1995) where the central goal in science education is to teach students to think critically about scientific models and data (Holmes et al., 2015).

Thus, Rais and Lamada (2010) emphasize that PBL provides an ideal environment for applying skills and enhancing the quality of a student's learning process, reaching a high cognitive level remains a key objective of the learning process. In this way, the good use and application of these tools allow analysis of the problem, proposing ideas, and executing a project, as a real simulation applied in several possible scenarios (refer to Appendices D, E for further details).

TABLE 4 Mathematical models applied to biotechnological processes.

Function	Application	Mathematical equation
Exponential growth	• *Bacterial growth* *Recursive function*	$P(t) = P_0 (1 + r)^t$
	• *Fermentation* *Logistic function*	$P(t) = \frac{a}{1 + Ce^{-kt}}$
	• *Compound interest*	$A = P\left(1 + \frac{r}{n}\right)^{nt}$
Exponential decrease	• *Radioactive decay over time*	$N = N_0 2^{\frac{-t}{x}}$
	• *Exponential decay model*	$N(t) = N_0 e^{-kt}$
	• *Depreciation*	$A = P_0 (1\text{-}r)^t$
Logarithmic	• *pH acidity level*	$pH = -\log_{10} a_{H^+}$
	• *pOH acidity level*	$pOH = -\log_{10} a_{OH^-}$
	• *Hydrogen ion concentration*	$\left[H^+\right] = 10^{-pH}$ $y = \log_a x$

As well as, PBL provides students with orientation to correlate the mathematics subject; with real life applications (Asija, 2011). The PBL development generated some proposals that could be part of the creation of bioenterprises that self-supply local and national markets, thus favoring the development of our country's productive system. At the national level, companies contributing to the national economy operate in the agri-food sector, specifically in food production using biotechnological methods, food safety (quality, conservation, etc.), seed production and crop improvement processes (CEIM Confederación Empresarial de Madrid-CEOE, 2002).

Likewise, as shown above, mathematics can contribute to the development of various projects, such as projects in the agricultural sector, as explained by Chávez Esponda et al. (2013), through the calculation of soil pH knowing the concentration of hydronium, which leads to the equation of a function of great utility for the study of soil characteristics, as well as the inverse process. This information is highly valuable for improving the soil conditions prior to crop establishment. Other widely used functions are the response curves, which allow the establishment of a relationship between crop yield and nutrients in a plot of land. The calculation of irregularly shaped land areas from field measurements and the calculation of the growth rate of a plant uses differential and integral calculus tools. However, the current study could be constrained to mathematical functions. It would be intriguing to conduct a fresh investigation that encompasses additional mathematical subjects, all while embracing the Project-Based Learning (PBL) approach using Artificial Intelligence (AI) education tools. Such an endeavor could yield benefits for high-need students across various global contexts, provided that classrooms incorporate suitable PBL project activities.

Finally, according to the results obtained from the opinion survey (Appendix F), we consider that the formative experience allowed the teacher to improve the mathematics teaching-learning and increase the percentage of approved students, while they increased their degree of motivation using experimental scientific designs PBL-based. Improving the skills and abilities developed by students to generate biotechnological solutions to problems in their environment and achieving a better potential to solve problems through logical reasoning.

5 Conclusion

The study was conducted with only 111 university-participating students, represented by three courses: Biochemistry and Pharmacy, Chemical Engineering and Business Administration carrers, representing about 15% of all first academic cycles at UTPL. It suggests that the findings are based on a small representative sample of the first cycle. However, it could be argued that as future work, we might increase the representative sample to all Biological Sciences and Medicine Faculties.

In this experience, the experimental and control groups showed significant differences ($p < 0.001$), demonstrating that PBL as a mathematical teaching-learning strategy provided promising results in the first academic cycles at UTPL. Moreover, teaching strategies strengthen scientific knowledge in students' critical thinking and problem-solving skills. It suggests that PBL can be applied in another classroom and provide opportunities for students to build self-confidence and demonstrate skills they cannot demonstrate on a traditional assessment.

5.1 Limitations and future work

The main limitations of this work are the sample size and potential bias. These limitations must be addressed in future work, such as increasing the sample size to increase the validity of the assessment of PBL activities, implementing blinding and randomization assignments to help ensure that participants are assigned to groups in an unbiased manner, and reducing the risk of selection bias.

Also, incorporating new methodologies focused on artificial intelligence (AI) models like ChatGPT into Project-Based Learning (PBL) can offer exciting opportunities to enhance student learning experiences. For example, encouraging students to utilize ChatGPT as a research tool to gather information, brainstorm potential solutions, analyze data, simulate scenarios and generate new ideas for their projects, to generate project documentation such as written reports, or develop interactive presentations to communicate their project findings and insights effectively, taking into account the ethical considerations of using AI.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

YJ-G: Writing – original draft, Writing – review & editing. OV-G: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1364640/full#supplementary-material

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