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THE PROJECT-BASED LEARNING METHOD IN MATHEMATICS INSTRUCTION FOR ENGLISH MAJOR STUDENTS AT TEACHER TRAINING COLLEGES IN CALLEJÓN DE HUAYLAS

O MÉTODO DE APRENDIZAGEM BASEADO EM PROJETOS NO ENSINO DE MATEMÁTICA PARA ALUNOS DO CURSO DE LETRATURA INGLESA EM FACULDADES DE FORMAÇÃO DE PROFESSORES EM CALLEJÓN DE HUAYLAS

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Abstract
The primary objective of this study was to determine the influence of the project-based learning method on mathematics learning among first-year students majoring in English at the Teacher Training Colleges of Callejón de Huaylas in 2022. In terms of methodology, this is a quantitative study; in terms of design, it is a quasi-experimental study. The sample consisted of 50 students divided into two homogeneous groups (control and experimental). The pretest results showed that the majority of students in the experimental group (84%) and the control group (88%) were at a beginner level in mathematics learning, while in the posttest, the experimental group was at a good level (76%) and the control group at a beginner level (72%). When testing the hypotheses, significant differences were found between the groups; the Mann-Whitney U test yielded a significant value (p=0.00; p<0.05) in the posttest, indicating that after applying the project-based method, the mathematics learning scores of the students in the experimental group improved. In conclusion, it was demonstrated that the application of the project-based learning method significantly influences mathematics learning.

Keywords: Mathematics Education. Project-Based Learning. Students.

Resumo
O objetivo principal deste estudo foi determinar a influência do método de aprendizagem baseado em projetos na aprendizagem da matemática entre os alunos do primeiro ano do curso de Formação de Professores de Inglês nas Faculdades de Formação de Professores de Callejón de Huaylas em 2022. Em termos de metodologia, trata-se de um estudo quantitativo; em termos de desenho, é um estudo quase-experimental. A amostra consistiu em 50 alunos divididos em dois grupos homogêneos (controle e experimental). Os resultados do pré-teste mostraram que a maioria dos alunos do grupo experimental (84%) e do grupo controle (88%) estava em um nível iniciante na aprendizagem da matemática, enquanto no pós-teste, o grupo experimental apresentou um bom nível (76%) e o grupo controle, um nível iniciante (72%). Ao testar as hipóteses, foram encontradas diferenças significativas entre os grupos; o teste U de Mann-Whitney apresentou um valor significativo (p=0,00; p<0,05) no pós-teste, indicando que, após a aplicação do método baseado em projetos, as notas de aprendizagem em matemática dos alunos do grupo experimental melhoraram. Em conclusão, demonstrou-se que a aplicação do método de aprendizagem baseado em projetos influencia significativamente a aprendizagem em matemática.

Palavras-chave: *Educação Matemática. Aprendizagem Baseada em Projetos. Alunos.*

1 INTRODUCTION

In the past, learning mathematics has been challenging in a variety of academic fields, particularly for students whose majors are not related to the exact sciences, as is the case with English majors at the Institute of Higher Pedagogical Education (IESPP) in Callejón de Huaylas. The perception that mathematics is based on abstract thinking, unrelated to the real world, has often led students to indifference and low motivation, which is reflected in their understanding and academic performance.

Internationally, according to a study conducted by the Organization for Economic Cooperation and Development (OECD, 2024), it was observed that over the past decade, in most OECD countries, adults have shown a decline in the acquisition of literacy, mathematics, and everyday problem-solving skills, with 18% failing to reach a basic level of proficiency in these areas; only Japan, Finland, Norway, the Netherlands, and Sweden have improved their proficiency levels in these skills. This is despite the fact that member states and social organizations have made significant efforts to strengthen the adult education system in recent years.

This issue is even more pronounced among adults from Latin American and Caribbean (LAC) countries; in fact, the 2022 Programme for International Student Assessment (PISA) revealed that adolescents transitioning from secondary school to university face learning difficulties in these areas; acquiring only the basic competencies necessary for their development in a social context (OECD, 2023). Regarding mathematics competencies, students in the region achieved an average of 373 points (25% at the basic level), which, compared to OECD students (average of 475 points, 69% at the basic level), is very deficient; thus highlighting that the teaching strategies applied in LAC countries are not appropriate, and that attention must be given to student performance, equity, and the investment of resources and technological tools in the educational sector (Inter-American Development Bank (“IDB”) and World Bank, 2024).

In this context, various studies in the region have also shown that college students exhibit deficiencies in mathematics when they begin their higher education. For example, in Ecuador, Rondón *et al*. (2024) found that students had difficulty understanding, applying, and solving mathematical problems, with 58% receiving a “fair” grade, 25% a “good” grade, and 8% a “failing” grade. Meanwhile, in Mexico, Herrera (2024) revealed

that the teaching of differential calculus in secondary school impacts the academic future of college students, who demonstrate a lack of knowledge and limited skills. In both studies, the authors considered the implementation of the project-based learning (PBL) method as a teaching strategy to improve this situation, finding favorable results.

Thus, one of the strategies most widely used by today's innovative teachers for teaching and learning mathematics is the MP, a methodological approach that promotes cooperative and context-based learning in the search for common solutions to mathematical problems (García-Martín & Pérez-Martínez, 2018). This method provides both knowledge and experience, all through the resolution of everyday situations, fostering the development of knowledge, patience, ingenuity, energy management (dedication), and, above all, perseverance.

With regard to Peru, the situation is no different from that described above for Latin America, given that in the 2022 PISA assessment of students' ability to solve complex problems, think critically, and communicate effectively, the average results were lower than those of 2018. In terms of mathematical skills, Peru ranks 59th out of 81 countries evaluated; compared to other countries in the region, it is outperformed by Chile, Uruguay, and Mexico, which rank 52nd, 53rd, and 57th, respectively; however, it outperforms Costa Rica (63), Colombia (64), Brazil (65), Argentina (66), Jamaica (68), and Panama (74) (Arias *et al*., 2023).

Despite these results, the 2022 PISA assessment highlights the country's shortcomings in the teaching strategies used for mathematics instruction at the secondary level, which has repercussions for higher education, where students arrive with poor performance in this subject. In this regard, it is reported that 34% of students achieved at least Level 2 proficiency in mathematics, which is significantly lower than the average for OECD countries (69%). At a minimum, these students can interpret and recognize, without direct instruction, how a simple situation can be represented mathematically (for example, comparing the total distance between two alternative routes or converting prices to another currency) (OECD, 2023).

In this vein, in addition to these findings, several national-level studies have highlighted the lack of mathematical skills among university students. This is the case with Vargas (2024), who, in an assessment of university students in Lima, demonstrated that the majority had a moderate level of mastery of mathematical competencies (71.7%),

with moderate proficiency in arithmetic operations (64.1%), problem-solving (51.1%), data interpretation (70.7%), and presenting results (55.4%). Similarly, Hilario (2021), Upon evaluating a sample of high school seniors, it was observed that most demonstrated only basic proficiency in mathematical skills; in other words, they had not acquired the necessary knowledge to begin higher education.

At the local level, students in the first cycle of the English specialization program at the public Teacher Training Colleges (IESPP) in the Callejón de Huaylas region are facing this problem; therefore, they are the subjects of this research, as there is growing concern that they have a low level of knowledge in mathematics. Their performance is poor; they express a desire to improve and state that they do not understand their teachers' lessons. The main causes of poor mathematics learning include, among others, inadequate teaching methodology, limited use of teaching materials, a lack of professional development for teachers, and the use of traditional teaching methods.

Another problem identified among English students in teacher-training programs is a lack of interest in the subject, low grades, insufficient mastery of the competencies outlined in the National Curriculum, poor performance in other subjects, dropping out of the course, grade repetition, and academic risk. Consequently, a certain number of students, upon graduation, will face limitations in their performance in mathematics due to the weaknesses they exhibited during their academic training.

Furthermore, they are affected by the policies and regulations administered by the Peruvian Ministry of Education (MINEDU), which are constantly changing, preventing the development of sustained efforts with positive results. Furthermore, there is a lack of training for teachers in methodologies and the use of teaching strategies that would improve learning in mathematics courses at IESPPs. Additionally, mathematics teachers exhibit poor planning, preparation, and execution of learning sessions, which does not contribute to improving mathematics learning.

Therefore, it is believed that the challenges faced by first-year students majoring in English at the IESPPs in Callejón de Huaylas can be addressed by implementing the MP strategy, as explained above, which will enable students to connect mathematical concepts with the environment in which they live and learn. The MP in mathematics undoubtedly promotes understanding of the content, as it is a method that facilitates interaction among students, which encourages the exchange of opinions and questions for

solving (mathematical) problems and helps them see the practical value of the subject, thereby increasing their interest and motivation to attend classes and fulfill their academic responsibilities.

1.1 Research objective

To determine the influence of the project-based learning method on mathematics learning among first-year students majoring in English at the Teacher Training Colleges of Callejón de Huaylas, 2022.

1.2 Rationale

At the theoretical level, this research is grounded in theoretical sources that address mathematics learning and its various dimensions. Thus, the findings of this study generate new insights into the variables examined and set a precedent for future research. Likewise, it confirms that the pedagogical approach of constructivism is useful for the teaching-learning process in mathematics, as it enables and encourages students to construct and define their own learning and to tackle any problem or situation that may arise in the future (Peiró, 2025).

On a practical level, this study enabled an assessment among teachers, taking into account the importance and purpose of this method, with the aim of identifying the influence of the MP on mathematics learning among first-year students majoring in English at the IESPPs in the Callejón de Huaylas region in 2022. Similarly, strategies were proposed to address this issue, and the conclusions reached will enable teachers to utilize this methodological teaching strategy.

Methodologically, the educational model of the IESPP in Huaraz and the curriculum for the English program are based on a competency-based approach; therefore, based on the study's findings, it is clear that the use of the MP is appropriate for teaching mathematics, with the aim of generating meaningful knowledge. The implementation of the MP involves a remarkable depth of experience and even the acquisition of new knowledge; this research clearly details its methodology.

Consequently, its application—aimed at fostering a better understanding of mathematics—challenges the belief that mathematics is "difficult."

On a social level, the social relevance of this dissertation directly benefits first-year English students enrolled in mathematics courses. Thus, it will indirectly benefit students at the two institutions involved in the study and their representatives. The theoretical utility of the results of this research aligns with the generation of new knowledge about MP, enabling students at both institutions to improve their education.

2 LITERATURE REVIEW

2.1 The project method

The project method is a model that focuses on what students do—on their active learning—where the university professor acts as a facilitator of learning, empowering students to take responsibility for their own learning and serving as a guide to help them develop their own competencies. (Toledo & Sánchez, 2018)

The project-based method (PBM) refers to an opportunity to break down individualism and promote contextualized, collaborative learning in an effort to find answers to the questions outlined. Therefore, it is very important that the instructor be able to guide and advise students in fostering and developing attitudes of respect, understanding, and participation in group work. (Mora, 2009)

According to Mora (2009), the MP is a teaching-learning unit characterized by features such as a curriculum based on the students' own needs; the use of real-world contexts that are common not only within the confines of the school but also in everyday life; and the active involvement of both teachers and students in the teaching-learning process; a focus on intellectual knowledge; pushing the boundaries of education based on the interdisciplinary nature of the unique characteristics of each scientific subject; the project-based teaching and learning process aims at social relevance and the overall significance of the subjects; and given that groups offer a significant number of advantages over other social forms of teaching and learning, it is clear that this style of instruction requires support.

The use of project-based learning (PBL) is of incalculable value, as it allows students to immerse themselves in an activity that interests them and whose outcome is learning; it fosters reasoning, creativity, and inquiry as students seek out and construct their own knowledge; it generates student-student and student-teacher interaction, thereby promoting emotional bonds, cooperation, community well-being, and collectivism, thereby facilitating the student's socialization—one of the functions of education and, consequently, of the method, which consists of a series of components, as shown in Figure 1 (Mora, 2009).

Figure 1

Components of the MP

Autonomous learning:	The student defines their interests and directs their learning.
Community engagement:	Learning connected to real-world problems in the environment.
Direct experience:	Contact with social and material reality, not just theoretical.
Problem contextualization:	Considering the complexity of real life when designing projects.
Orientation towards real change:	Seeks to transform reality, not just describe it.
Active participation:	Everyone contributes according to their interests and abilities at all stages.
Individual and collective commitment:	Shared responsibility for the project.
Use of creativity and activity:	Includes imagination, play, and physical action.
Role reversal:	More active students and teachers as guides
Productive approach:	Process and final result are integrated.

The MP is based on the theory of the project method, which holds that any action undertaken by a student takes on the nature of a "project," provided that the student undertakes it with the intention of achieving a specific goal—whether that involves solving a (mathematical) problem, building a machine, watching a sunset, or simply listening to a Beethoven symphony. This theory does not associate this methodology with any specific scientific field, nor does it require the active participation of students. Thus, participants involved in a theatrical production were carrying out a project, just as the audience members watching the performance were. (García & Pérez, 2018)

2.2 Mathematics learning

It is the process of acquiring and retaining knowledge, attitudes, and values, which fosters skills through instruction and experience; mathematics is not built in a vacuum but upon the foundations of knowledge established by our predecessors; The purpose of teaching mathematics is not merely to train students to solve problems whose solutions they already know, but to prepare them to solve problems they have not yet been able to solve. To this end, they must be accustomed to authentic work that involves not only solving the problem but also applying prior knowledge to its solution (Ayasta, 2017).

Understanding the nature of mathematical learning is essential for teachers to be aware of and comprehend their students' thinking abilities in the context of the tasks they are assigned to solve. Thus, the focus is on the teacher's understanding of the procedures involved in grasping mathematical goals and the phenomena arising from these processes, with particular attention to the knowledge that underpins mathematical content: common errors, epistemological gaps, mental schemas linked to specific content, etc. (Sosa *et al*., 2015).

The value of education, thanks to mathematics, lies in the fact that it teaches us to reason logically, helps us develop problem-solving and decision-making skills, and improves our ability to express ourselves more clearly. It is difficult to find an area where mathematics is not relevant, because through it we learn life skills, as this discipline permeates every aspect of our environment. Most environments and different fields take numerical skills into account, and some even consider them absolutely necessary. A wide range of activities, such as cost calculation, risk assessment and quality control, modeling, and problem-solving, depend on the application of statistics and probability. (Cuoghi, 2023)

In this regard, given the ever-changing landscape of the world we live in—particularly with regard to technological innovations—the demand for numerical knowledge is on the rise. Indeed, the relevance of mathematics lies in the fact that it cannot be replaced; it is useful for defining relationships based on logical connections, such as those between points and numbers. However, in the modern era, this field goes beyond the analytical simplicity of numbers, advancing into non-quantitative logical

frameworks. In this context, its application to computer science today is responsible for the technical advancements that are dazzling the entire world. (Cuoghi, 2023)

2.3 Theory of attitudes toward mathematics

In the teaching and learning of mathematics, students' attitudes toward the subject are extremely important, as they influence their success in the subject. These attitudes are shaped by teaching style, the school environment, the family, and students' perceptions of school. Even when teachers believe they are presenting mathematics to students in a realistic and context-appropriate manner, many students choose to avoid mathematics because of how it is typically presented in the classroom and how they perceive it. According to the findings of several studies, having a positive attitude toward mathematics helps children succeed in the subject. (Palomino, 2018)

3 METHODOLOGY

3.1 Approach, type, and design

In accordance with the adopted approach, this is quantitative research, as it holds that knowledge must be objective and that it is generated through a deductive process in which previously formulated hypotheses are tested using numerical data and inferential statistical analysis. (Otzen & Manterola, 2017)

In terms of its purpose, this is applied research, which aims to solve a specific problem or address a particular issue, focusing on the pursuit and consolidation of knowledge for its application and, consequently, for the enrichment of cultural and scientific development. (Neill & Cortez, 2018).}

The research design is quasi-experimental, cross-sectional, with two intact groups. The most commonly used quasi-experimental designs follow the same logic and involve comparing treatment and control groups using random estimates. Although quasi-experiments are more vulnerable to threats and validity issues than randomized trials, they do not require random assignment to experimental groups and are therefore generally more feasible than randomized trials. (Godino *et al*., 2010)

3.2 Participants

The study population consisted of 50 students (two classes) in the first year of the English major at two public teacher-training colleges in the Callejón de Huaylas region, who took the mathematics course during the 2022 semester.

The sample consisted of an experimental group of 25 students of both genders from IESPP-Huaraz and a control group of 25 male and female students from IESPP IARO-Yungay. All of whom were in the same program and cycle and were between the ages of 18 and 20. The 25 students in each group were selected at random after the inclusion and exclusion criteria were applied.

According to Bavaresco (2013), a population census involves the study of all members of a population to obtain specific information. The author notes that the primary objective of such studies is to gather information on the parameters or characteristics of the population, which are clearly defined and delimited—an aspect addressed by applying the census to the national population, that is, to all its members.

For this research, we used purposive sampling, in which "the elements are chosen based on criteria or judgments pre-established by the researcher" (Arias, 2016, p. 85); in this case, the criteria listed below. The study sample included first-year students majoring in English at the IESPPs in Callejón de Huaylas who were enrolled for the first time and who provided informed consent. According to Bavaresco (2013), students in the first cycle of the English major at the IESPPs in Callejón de Huaylas who did not attend classes regularly, students enrolled for the second time, and those who refused to sign the informed consent form were excluded from the study sample.

3.3 Instruments

For the independent variable—the application of the project method—the observation technique was used, and the rating scale was employed as the instrument to adequately control this variable and its application in the mathematics learning process, meeting the requirements established in the indicators and items. Regarding the dependent variable, mathematics learning, the survey technique was employed, and the

written test was used as the instrument for the dimensions: mathematical knowledge and specific performance.

A survey is a data collection technique that allows researchers to engage with participants through pre-designed questionnaires. “Surveys are widely used as a research method, as they allow data to be obtained and processed quickly and efficiently” (Casas *et al*., 2003, p. 143). Thus, to investigate, characterize, predict, and/or explain a set of characteristics, a dataset is collected and analyzed from a sample of typical cases within a broader population or universe.

Expert judgment was used to determine the validity of the data collection instruments; three experts holding doctoral degrees were selected, who evaluated the instruments using the corresponding validation forms (Appendix 6.5), where they rated the items based on the criteria of clarity, methodology, consistency, and relevance. Similarly, for their evaluation, Aiken’s V statistic was applied, yielding a coefficient of V = 0.875, indicating high agreement among the opinions of the consulted experts and confirming the validity and reliability of the instrument for its application in measuring the variable; these results were necessary for decision-making regarding these instruments.

In this regard, it is worth noting that validity refers to the ability of a measurement instrument to quantify, in a meaningful and appropriate manner, the trait for which it was designed (Argibay, 2006). To determine the reliability of the instruments, a similar group of first-cycle students was selected, a pilot study was conducted, and the internal consistency measurement technique was applied; thus, the reliability for the Project Method Questionnaire was 0.90 (Cronbach’s alpha), and for the Mathematics Learning Questionnaire, it was 0.81 (Kuder-Richardson).

3.4 Procedure

A rating scale and a questionnaire were used to conduct the study. Both instruments were administered before and after the intervention to determine which group showed improvement in mathematics learning. The data obtained through the application of the data collection instruments were organized according to the objectives established

in the research project; they are presented in tables with their respective analysis and interpretation using SPSS software (trial version).

A descriptive analysis was conducted using simple frequency counts and percentage measures of the variables and dimensions for each group (GE and GC) in the pre- and post-tests, where the Project Method was evaluated at the levels of Poor, Fair, and Good; Additionally, the data obtained from the assessment of mathematical learning were compared using the levels Beginner, Fair, Good, and Outstanding; these findings are presented in contingency tables. In testing the hypotheses, the decision was made to use the nonparametric Mann-Whitney U test to compare the scores obtained.

4 RESULTS

According to the results of the general objective (Table 1), the pretest evaluation found that the majority of students in the experimental group (84%) and the control group (88%) were at a beginner level in mathematics. Meanwhile, after applying the project-based method in teaching this course, the majority of students in the experimental group achieved a good level (76%) on the post-test, while most students in the control group, who were taught using traditional strategies, remained at the beginner level (72%). In other words, at the start of the study, students in both groups had the same abilities in mathematics, but after applying the project-based method, students in the experimental group performed better than those in the control group.

Table 1

Assessment of mathematics learning levels in the study groups before and after implementing the project-based learning method

Assessment	Levels	Cluster			
		Experimental		Control	
Pretest	Start	21	84%	22	88%
	Regular	3	12%	3	12%
	Well	1	4%	0	0%
	Outstanding	0	0%	0	0%
Posttest	Start	0	0%	18	72%

	Regular	4	16%	6	24%
	Well	19	76%	1	4%
	Outstanding	2	8%	0	0%
Total		25	100%	25	100%

In the analysis of data normality, the Shapiro-Wilk test was applied to evaluate groups of 25 students ($n < 50$). Table 8 shows that, for all variables compared in both the pre- and post-tests, at least one of the groups (GE/GC) exhibited a p-value below the established significance threshold ($p < 0.05$), which demonstrates that the data for these variables and dimensions do not conform to a normal distribution; therefore, to test the hypothesis proposed in the study, the decision was made to apply the nonparametric Mann-Whitney U test for independent samples, evaluating significant differences between the measures obtained in the experimental group compared to the control group.

Table 2

Assessment of the normal distribution of the variable and dimensions

Variable / Dimension	Proof	Cluster	Shapiro-Wilk		
			Statistical	gl	p
V2. Mathematical learning	Pretest	GE	0.87	25	0.00
		GC	0.94	25	0.13
	Posttest	GE	0.85	25	0.00
		GC	0.96	25	0.42
D1. Problem solving	Pretest	GE	0.90	25	0.02
		GC	0.94	25	0.12
	Posttest	GE	0.84	25	0.00
		GC	0.92	25	0.04
D2. Personal strengths for making decisions	Pretest	GE	0.88	25	0.01
		GC	0.89	25	0.01
	Posttest	GE	0.87	25	0.00
		GC	0.87	25	0.00
D3. Strategies for translating quantities	Pretest	GE	0.90	25	0.02
		GC	0.94	25	0.15
	Posttest	GE	0.92	25	0.04
		GC	0.89	25	0.01

In the results of the Mann-Whitney U test for mathematics learning outcomes and each of its dimensions (Table 3), when evaluating the sum of the mean ranks between the experimental and control groups (EG/CG), a significance value of p = 0.65 was obtained in the pretest evaluation, which is greater than the established margin of error (p > 0.05), indicating that, in the initial assessment of the students, mathematics learning scores do not show significant differences. In contrast, the posttest yielded a significance value of p = 0.00, which was less than the established margin of error (p < 0.05), indicating that after applying the project-based method, the mathematics learning scores and scores for each of its dimensions among students in the experimental group showed significant differences compared to the control group.

Table 3

Mathematics learning outcomes in the experimental group vs. the control group before and after implementing the project-based learning method

	Proof		Average range	Sum of ranks	Mann-Whitney U		
					Statistical	Z	p
Learning mathematics	Pretest	GE	26.06	651.50	298500.00	-0.45	0.65
		GC	24.94	623.50			
	Posttest	GE	36.98	924.50	25500.00	-5931.00	**0.00**
		GC	14.02	350.50			
Resolution of problematic situations	Pretest	GE	25.62	640.50	309500.00	-0.08	0.93
		GC	25.38	634.50			
	Posttest	GE	34.60	865.00	85000.00	-4643.00	**0.00**
		GC	16.40	410.00			
Personal strengths for making decisions	Pretest	GE	22.48	562.00	237000.00	-1699.00	0.09
		GC	28.52	713.00			
	Posttest	GE	32.00	800.00	150000.00	-3282.00	**0.00**
		GC	19.00	475.00			
Strategies for translating quantities	Pretest	GE	27.56	689.00	261000.00	-1439.00	0.15
		GC	23.44	586.00			
	Posttest	GE	36.74	918.50	31500.00	-5741.00	**0.00**
		GC	14.26	356.50			

5 DISCUSSION

The analysis of the findings addressed the research question that motivated this study, as it was determined that solving real-world mathematical problems within the context of a community service project led by first-year English majors at the Pedagogical Institutes of Callejón de Huaylas promotes more effective and meaningful learning in this academic area, a finding confirmed by testing the general research hypothesis using the Mann-Whitney U test, which showed that after applying the project method (post-test), the mathematics learning scores of students in the experimental group differed significantly from those of the control group ($p=0.00$), whereas at the beginning of the study (pre-test) they were on equal footing ($p=0.65$), which is consistent with the studies by Córdova-Espinoza *et al*. (2024), Apaza *et al*. (2022), Hilario (2021), and Llatas (2020), who, in comparing the experimental group treated with the PBL methodology and the control group addressed with strategies traditional methods found significant differences in the acquisition of mathematical skills ($p<0.01$).

Likewise, the findings align with studies from Ecuador, where Delgado-Rodríguez *et al*. (2024) and Rondón *et al*. (2024) determined that the PBL methodology significantly improves ($p < .001$) students' academic performance in terms of mathematical content, active participation, and academic achievement. In other words, the evidence found in this research aligns with other pedagogical experiences where the project-based methodology was applied to teach mathematical content, thereby reaffirming the effectiveness of this educational strategy in teaching practice by promoting quality learning that is relevant to students' social and professional performance.

In this regard, the study highlights that student taught using the active, project-based methodology progressed from a "beginner" level of mathematics learning (84%) to a "good" level (76%), a finding similar to that reported by Hilario (2021), who, after implementing ICT-based project-based learning in mathematics instruction, found that students in the experimental group reported a 46% increase in achievement level, while those in the control group increased by 13% in process level.

For their part, Apaza *et al*. (2022) also corroborates these results, as after applying PBL, 81% of the students achieved a high level of achievement, representing a 27%

difference compared to the control group's achievement level (54%). Meanwhile, Llatas (2020) found that the experimental group increased their knowledge and demonstrated greater learning in mathematics than the control group, thus demonstrating the effectiveness of the project-based methodology. Similarly, Herrera (2024), in Mexico, demonstrated a favorable transition in the experimental group regarding performance in differential calculus. This evidence reinforces the fact that the project-based method improves students' academic performance, leading to greater acquisition of meaningful knowledge.

It was also found that the project-based learning method significantly influences students' ability to solve mathematical problems, a finding supported by the results of the Mann-Whitney U test used to test the first specific research hypothesis. The test established that after implementing the project-based learning method (posttest), the scores on mathematical problem-solving tasks among students in the experimental group showed significant differences compared to the control group ($p=0.00$), whereas at the beginning of the study (pretest) they were on equal footing ($p=0.93$). This aligns with research from Ecuador, where Delgado *et al*. (2024) and Rondón *et al*. (2024) revealed that the project-based learning methodology significantly improves ($p<0.01$) competencies for solving practical problems, as well as communication and collaboration.

These findings are consistent with those of Herrera (2024) in Mexico, who observed positive progress among students in problem formulation, problem-solving, and analysis of results following the implementation of project-based learning strategies. These results indicate that learning based on students' lived experiences throughout the project successfully enhanced their ability to solve real-world problems through well-structured, carefully designed, and organized situations.

Furthermore, the study found that the project-based method significantly influences students' recognition of their personal strengths in making decisions regarding real-world problem situations, as confirmed in the second specific hypothesis through the Mann-Whitney U test, which established that after implementing the project-based method (post-test), the scores for personal strengths in decision-making regarding problematic events among students in the experimental group showed significant differences compared to the control group ($p=0.00$), whereas at the beginning of the study (pretest) they were on equal footing ($p=0.09$). This is similar to evidence from Ecuador,

where Delgado *et al*. (2024) and Rondón *et al*. (2024) found that the project-based learning method significantly enhanced students' critical skills in coping with challenges in their professional lives ($p<0.01$).

This is consistent with the findings of Hilario (2021), who revealed that project-based learning strategies have a significant impact on students' mathematical competencies in identifying and understanding quantities, as well as in managing data and uncertainty. This implies that the project-based methodology enables students to develop socio-emotional and cognitive skills and abilities that aid decision-making in real-world, concrete situations through the application of academic concepts.

Finally, the research demonstrated that the project-based method significantly influences the learning of strategies for translating quantities into numerical expressions in mathematics. This was tested in the third specific hypothesis using the Mann-Whitney U test, which established that after applying the project-based method (post-test), the learning scores for the use of strategies to translate quantities into numerical expressions among students in the experimental group showed significant differences compared to the control group ($p=0.00$), whereas at the beginning of the study (pretest) they were on equal footing ($p=0.15$), consistent with the Ecuadorian studies by Delgado *et al*. (2024) and Rondón *et al*. (2024), who found that content comprehension improves significantly with the project-based learning methodology ($p<0.01$), helping students apply their knowledge to everyday problems.

This supports the findings of Apaza *et al*. (2022), who revealed that project-based teaching strategies have a significant influence on the academic performance of engineering students by strengthening their knowledge in this area, promoting research and the application of innovative technologies, as well as enhancing individual and team performance. This indicates that the project-based method is characterized by an action plan that stimulates and encourages individual preparation by bringing mathematical content closer to students' experiences and having them interpret numerical expressions in the context of a real-world problem.

Therefore, the study confirms that this teaching methodology is well accepted by students at different academic levels and in various courses, as it promotes collaborative, motivating, and highly relevant learning for their lives, as perceived by Monge and Suárez (2023), in Costa Rica, who revealed that students rate the workshops using project-based

learning highly (90.0%), feeling motivated and satisfied with the teaching methods implemented, thus reaffirming the teaching approach to mathematics for putting their skills into practice, strengthening teamwork, and decision-making.

In this regard, Herrera (2024) notes that the project-based methodology is an active teaching approach that can be applied in courses other than mathematics. In this regard, the effectiveness of the project-based method has been demonstrated in other academic areas, as in the case of Quispe (2023), who showed that the method has a significant impact ($p=0.00$) on social science learning, improving students' understanding of the interaction between natural sciences, information management, and active participation. Likewise, Charcape (2020) revealed that the project-based teaching methodology significantly improves ($p=0.00<0.05$) the knowledge acquired by students in the health management course.

In addition to these findings, the study highlights the need to monitor teaching methods applied in the secondary education context to help enhance students' strengths in science and technology, which is one of the main challenges for higher education institutions that admit students with cognitive difficulties in mathematics, as noted by Herrera (2024), in Mexico, noting that mathematics instruction in secondary school impacts the academic future of university students, given that these students lack knowledge and possess few skills.

This is why the expansion of access to higher education and the resulting increase in mathematics instruction have posed challenges for the education system in implementing active methodologies with an emphasis on information and communication technologies, as demonstrated by Vargas *et al*. (2021) in Colombia, who revealed that project-based learning strategies with a techno-pedagogical design improved students' ability to apply content in practice, enhancing their statistical comprehension, communication, critical thinking, and technological skills, as the use of technology improves data literacy. Similarly, in the Costa Rican context, Monge and Suárez (2023) found that, when implementing project-based learning to strengthen mathematics instruction, the use of technology positively contributed to the development of teaching strategies.

Thus, the study has significant implications from educational, social, and personal perspectives, as it offers an alternative approach to understanding mathematical problem-

solving and its practical application, given the many ongoing debates regarding teaching methodologies and pedagogy. These topics have been discussed in various ways and are extremely important for education as a whole, given that, when discussing them, one must also reflect on issues that directly or indirectly affect this process.

6 CONCLUSION

The application of the project-based learning method significantly influences mathematics learning and each of its dimensions: problem-solving, personal decision-making skills, and strategies for interpreting quantities among first-cycle students majoring in English. Students taught using this methodology outperformed those in the control group in their ability to understand, analyze, and interpret real-life mathematical problems, leading to significantly improved academic performance.

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