

Active Methodologies and Academic Performance in Mathematics: A Quasi-Experimental Study in Ecuadorian Institutions

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ABSTRACT:

This study examines the impact of active methodologies combined with diversified teaching materials, on academic achievement and student satisfaction in mathematics. A total of 679 students and 20 mathematics teachers from four secondary and high school institutions in south of Ecuador participated. A quasi-experimental pretest-posttest design without a control group was adopted. Achievement was measured through official grade averages and satisfaction through a Likert-scale survey validated by expert judgment. Normality was checked with the Kolmogorov-Smirnov test and pre-post comparisons with the Wilcoxon signed-rank test ($\alpha=0.05$). Results showed statistically significant improvements in achievement across all four institutions ($p=0.0001$), with a mean gain of 0.57 points. Teacher satisfaction reached 83.0% and student satisfaction 75.5%. It is concluded that planned, combined implementation of active methodologies significantly improves both mathematics achievement and satisfaction..

Keywords: Teaching methodology, teaching materials, academic performance.

Introduction

Teaching mathematics remains one of the most persistent challenges of today's education systems. The results of standardized tests at the global level recurrently show low performance in this subject, especially in secondary and high school, where the progressive abstraction of content requires overcoming the traditional expository class (Ruiz-Peralta & Reyes-Acaro, 2025; Hui & Mahmud, 2023). In Latin America, the situation is particularly worrying: educational indicators show a notable gap between expected and achieved learning, which has an impact both on academic development and on the insertion of students in a world that demands logical-quantitative thinking (Rehman et al., 2024; Zakariya, 2022). Faced with this panorama, the scientific community has intensified the search for didactic alternatives that give the student back the leading role in their own learning process.

Active methodologies have emerged as a consistent pedagogical response to the limitations of the transmissive model. Anchored in constructivist and sociocultural principles, they propose that knowledge is actively constructed through the interaction of the student with the content, with their peers and with the environment, its application fosters transversal competencies such as critical thinking, creativity, effective communication and teamwork, essential skills in the twenty-first century (Zeng et al., 2024; Jaramillo-Mediavilla et al., 2024). In the field of mathematics, these strategies have also been shown to reduce anxiety towards the subject and increase students' intrinsic motivation (Hui & Mahmud, 2023; Lo & Hew, 2020). Among those with the greatest empirical support are Problem-Based Learning, Project-Based Learning, gamification, and cooperative learning, whose effectiveness has been documented at different educational levels and cultural contexts (Siller & Ahmad, 2024; Ssali et al., 2025).

Problem-Based Learning (PBL) starts from authentic problem situations to trigger learning, requiring the student to activate prior knowledge,

investigate, reason and propose well-founded solutions. In mathematics, this methodology has shown favorable results both in performance and in the development of logical thinking and modeling capacity (Caridade, 2022). The systematic review by Ssali et al. (2025) confirms that PBL consistently improves conceptual understanding and knowledge transfer in secondary mathematics education. In the same vein, Ayari et al. (2025) documented, through a meta-analysis, that its effects go beyond performance and have a positive impact on interdisciplinary problem-solving skills; a finding that converges with that of Yuhana and Fajari (2025), who reported cross-sectional effects of PBL on secondary level cognitive competencies.

Gamification, understood as the incorporation of game mechanics, dynamics, and aesthetics in non-playful educational contexts, has attracted special interest due to its potential to increase engagement and motivation in mathematics (Kim & Castelli, 2021; Kalogiannakis et al., 2021). Its impact on the affective dimension is particularly valuable in a subject that historically generates negative attitudes. Fuentes-Riffo et al. (2023) showed that gamification in geometry classes significantly improves students' attitudes and reduces the perception of difficulty. In a closer context, Espinosa-Pinos et al. (2024) demonstrated, with Ecuadorian high school students, that the use of gamification favors the understanding of abstract concepts by creating more interactive and motivating environments. Ramírez Ruiz et al. (2024) add that its positive effects on school engagement translate into greater participation, perseverance, and satisfaction with *aprendizaje*. la motivation in mathematics (Kim & Castelli, 2021; Kalogiannakis et al., 2021). Its impact on the affective dimension is particularly valuable in a subject that historically generates negative attitudes. Fuentes-Riffo et al. (2023) showed that gamification in geometry classes significantly improves students' attitudes and reduces the perception of difficulty. In a closer context, Espinosa-Pinos et al. (2024) demonstrated, with Ecuadorian high school students, that play applied to geometry favors the understanding of

abstract concepts by creating more interactive and motivating environments. Ramírez Ruiz et al. (2024) add that gamification has positive and significant effects on school engagement, translating into greater participation, perseverance, and satisfaction with learning.

Cooperative learning is perhaps the active methodology with the longest research trajectory in mathematics education. By organizing students into small groups oriented towards common goals, it promotes positive interdependence, individual responsibility, and the development of interpersonal skills (Zach et al., 2023). Talkhan et al. (2025) expanded on this finding by confirming that such effects are maintained at different educational levels and cultural contexts. For their part, Mendo-Lázaro et al. (2022) added that cooperative work contributes to the achievement of higher quality academic goals and strengthens group cohesion and a sense of belonging.

Student satisfaction, understood as the subjective assessment of the learning experience, has been identified as a significant predictor of performance and continuity in STEM studies (Jiménez-Jiménez et al., 2025). Zakariya (2022) demonstrated that interventions that strengthen mathematical self-efficacy produce sustained increases in satisfaction, motivation, and performance. Granello et al. (2025) point out that positive mathematical self-concept is consolidated when students experience sustained success in challenging but achievable activities, a condition that active methodologies naturally favor. Camacho-Morles et al. (2021) also stressed that emotions such as satisfaction and enjoyment fundamentally mediate between learning experiences and academic outcomes.

In Latin America, the implementation of active methodologies in mathematics has been articulated with the use of innovative teaching materials and technological tools. Ruiz-Peralta and Reyes-Acaro (2025) highlight that the strategic selection of resources adapted to the educational level and the profile of the student is decisive for the effectiveness of any pedagogical intervention. The integration of digital

technologies and, more recently, generative artificial intelligence tools opens up new possibilities for personalizing teaching and expanding access to quality resources in the region (Cordero et al., 2025). However, the systematic adoption of these strategies by teachers remains limited, in part due to the limited teacher training available and the absence of empirically validated intervention models in Latin American contexts (Fuentes-Riffo et al., 2023; Siller & Ahmad, 2024).

In Ecuador, university linking projects with society represent a strategic channel to connect academic training with the educational needs of the local environment. Through this, university students act as agents of pedagogical innovation in basic education and high school institutions, enriching the work of teachers with updated teaching strategies. This modality not only benefits students from the receiving institutions, but also strengthens the pedagogical skills of future professionals. However, empirical evidence on the actual impact of these interventions on mathematics performance and satisfaction remains scarce, especially in quasi-experimental studies that simultaneously span several institutions (Hui & Mahmud, 2023; Rehman et al., 2024).

In this framework, this research evaluates the impact of implementing Problem-Based Learning, Project-Based Learning, gamification and cooperative learning, articulated with didactic materials designed for each level, on the performance and satisfaction of 679 students from four educational institutions in Ecuador. The intervention was carried out by university students within a project of linkage with society, which gives it an applied dimension of particular relevance. Prior to the intervention, a diagnosis was made on the use of active methodologies and didactic materials by the 20 teachers of the participating institutions, in order to characterize the pedagogical starting point of each context. The results of this research aspire to contribute with solid empirical evidence to the academic debate on the effectiveness of active methodologies in the teaching of mathematics in Latin America, and to offer concrete inputs for

the design of educational policies and teacher training programs aimed at pedagogical transformation.

Method

Research Approach and Design

This study adopts a quantitative approach with a quasi-experimental pre-test-posttest design without random assignment, since it worked with groups already constituted in four educational institutions. This modality is common in educational research when the context prevents randomization, but it is necessary to evaluate the effect of an intervention on measurable variables (Campbell & Stanley, 1963; Gray, 2023). Its scope is descriptive-inferential: in addition to measuring the change in performance before and after the intervention, it describes the level of student satisfaction. The work was developed during the 2024-2025 school year within the

framework of a university linkage project carried out under teaching supervision.

Population and sample

The population was composed of secondary and high school students and mathematics teachers from four educational institutions in Ecuador. The final sample was 679 students and 20 teachers, distributed among the four institutions, with an approximate average of 170 students and 5 teachers per center. The sampling was intentional non-probabilistic, a frequent criterion in quasi-experimental research (Gray, 2023), since the participation of the institutions responded to their link with the university project. Students enrolled regularly, with attendance of at least 80% to the sessions and with grades recorded at both measurement times were included. The participating teachers were responsible for the mathematics subjects in the intervened groups.

TABLE 1 *Distribution of the sample by educational institution*

Institution	Educational level	No. of students	No. of teachers	Total sample
Institution 1	Secondary and high school	148	5	153
Institution 2	Secondary and high school	142	5	147
Institution 3	Secondary and high school	156	5	161
Institution 4	Secondary and high school	233	5	238
Total	—	679	20	699

Source: Authors.

Description of the intervention

The intervention was designed and implemented by university students of a university career, under teaching supervision, within the framework of a project of linkage with society, the process was organized in three phases: initial diagnosis, implementation and subsequent evaluation. In the central phase, the interns carried out teaching-learning sessions in the four institutions, applying the methodologies in a planned and contextualized way to the secondary and baccalaureate curriculum correspondingly.

Data collection tools

Three instruments were used for data collection. The diagnostic survey of teachers was a five-option Likert scale (1 = Never, 2 = Almost never, 3 = Sometimes, 4 = Almost always, 5 = Always), applied to the 20 teachers before the intervention, with the aim of characterizing the previous use of active methodologies and establishing the pedagogical baseline. The student satisfaction survey also used a five-choice Likert scale (1 = Totally dissatisfied to 5 = Totally satisfied), applied to the 679 students at the end of the intervention. The official grade records provided the mathematics averages of

each student in the pre-test and post-test periods, which made it possible to evaluate the change in performance without the need for additional tests, thus guaranteeing the validity of the measurement.

Diagnostic survey of teachers. A five-choice Likert scale instrument (1 = Never, 2 = Almost never, 3 = Sometimes, 4 = Almost always, 5 = Always), before the intervention. Its purpose was to characterize the previous use of active methodologies and didactic materials in mathematics classes, constituting the baseline of the pedagogical context of the institutions.

Student satisfaction survey. A five-choice Likert scale instrument (1 = Totally dissatisfied, 2 = Dissatisfied, 3 = Neither satisfied nor dissatisfied, 4 = Satisfied, 5 = Totally satisfied), applied to the 679 students at the end of the intervention. It evaluated the level of satisfaction with the active methodologies and didactic materials used during the teaching-learning process.

Official grade records. The general mathematics averages of each student corresponding to the period before the intervention (pre-test) and the period after (post-test) were collected, from the official academic records of each educational institution. This documentary source made it possible to evaluate the change in academic performance without the need to apply additional tests, which guaranteed the validity of the measurement.

Validity of instruments

The content validity of the two questionnaires was established through the judgment of three specialists in mathematics education, research methodology, and instrument design. Each expert independently assessed the relevance, clarity, and coherence of the items, and their suggestions were incorporated before the final application, following the standards for instrument validation in quantitative research (Gray, 2023).

Data collection and analysis procedure

Data collection was organized in three moments: prior to the intervention, the diagnostic survey was applied and the grades of the previous period were collected; During 2024-2025, the intervention was carried out in the four institutions simultaneously; and at the end, both the ratings of the intervened period and the satisfaction survey were collected.

The statistical analysis was performed with the SPSS software (version 25). To compare performance before and after the intervention, the Wilcoxon test was used for related samples, after verification of normality with the Kolmogorov-Smirnov test ($\alpha = 0.05$).

Results

Diagnosis of the use of active methodologies in mathematics teachers

The first specific objective was to diagnose the previous use of active methodologies and didactic materials among mathematics teachers in the four institutions. A Likert instrument was applied to 20 teachers: Institution 1 ($n=4$), Institution 2 ($n=2$), Institution 3 ($n=3$) and Institution 4 ($n=6$). The results by dimension are presented below:

Training and general application of innovative methodologies

The diagnosis showed that training in innovative methodologies is irregular throughout the whole. As Table 1 shows, 'sometimes' was the predominant response in three of the four institutions, indicating that continuing education is far from being a systematic practice. The case of Institution 4 is striking, where 33.3% of teachers stated that they had never received this type of training; at the opposite extreme, Institution 3 registered the most favorable trend, with 33.3% who indicated that they always received it.

TABLE 2 *Teacher training in innovative methodologies by institution*

Institution	Never	Almost never	Sometimes	Almost always	Always
Institution 1 (n=4)	25,0%	0,0%	75,0%	0,0%	0,0%
Institution 2 (n=2)	0,0%	50,0%	50,0%	0,0%	0,0%
Institution 3 (n=3)	0,0%	0,0%	66,7%	0,0%	33,3%
Institution 4 (n=6)	33,3%	0,0%	50,0%	16,7%	0,0%

Source: Authors.

Frequency of use of specific active methodologies

Table 2 presents the frequency of use of the four active methodologies in each institution. As for gamification, Institution 1 applies it sometimes (50%) and almost never (25%), with 25% always doing it; Institution 2 shows the lowest profile: 50% almost never use it and 33.3% only sometimes. Institution 3 stands out favorably, with 66.7% using it sometimes and 33.3% always. Institution 4 has a similar distribution to Institution 1, with 66.7% using it sometimes and 16.7% almost never. Overall, gamification is the methodology with the least systematic presence in the whole. Problem-based PBL shows a more homogeneous pattern between institutions: Institution 1 applies it almost always (75%) and sometimes (25%); Institutions 2 and 4 have an

equitable distribution between sometimes and almost always (50% each option); while Institution 3 uses it only sometimes (100%). Project-based PBL is the methodology with the greatest presence: in Institution 1, 75% apply it almost always and 25% always; in Institution 2 100% do it almost always. Institution 3 presents a more heterogeneous distribution (almost never 33.3%, sometimes 33.3%, always 33.3%), and Institution 4 shows frequent use with 50% sometimes and 33.3% almost never. Cooperative learning registers the highest and most consistent levels: in Institution 1 50% always use it and 25% almost always; in Institution 3, 66.7% always use it; Institution 2 distributes its use between sometimes and almost always (50% each option); and Institution 4 presents an equitable distribution between sometimes, almost always and always (33.3% each).

TABLE 3 *Frequency of application of active methodologies in mathematics (synthesis by institution)*

Methodology	Institution	Never	Almost never	Sometimes	Almost always	Always
Gamification	I1 (n=4)	0,0%	25,0%	50,0%	0,0%	25,0%
	I2 (n=2)	16,7%	50,0%	33,3%	0,0%	0,0%
	I3 (n=3)	0,0%	0,0%	66,7%	0,0%	33,3%
	I4 (n=6)	16,7%	16,7%	66,7%	0,0%	0,0%
PBL (Problems)	I1 (n=4)	0,0%	0,0%	25,0%	75,0%	0,0%
	I2 (n=2)	0,0%	0,0%	50,0%	50,0%	0,0%
	I3 (n=3)	0,0%	0,0%	100,0%	0,0%	0,0%
	I4 (n=6)	0,0%	0,0%	50,0%	50,0%	0,0%
PBL	I1 (n=4)	0,0%	0,0%	0,0%	75,0%	25,0%

(Projects)	I2 (n=2)	0,0%	0,0%	0,0%	100,0%	0,0%
	I3 (n=3)	0,0%	33,3%	33,3%	0,0%	33,3%
	I4 (n=6)	0,0%	33,3%	50,0%	16,7%	0,0%
Cooperative Learning	I1 (n=4)	0,0%	0,0%	25,0%	25,0%	50,0%
	I2 (n=2)	0,0%	0,0%	50,0%	50,0%	0,0%
	I3 (n=3)	0,0%	0,0%	33,3%	0,0%	66,7%
	I4 (n=6)	0,0%	0,0%	33,3%	33,3%	33,3%

Note: The percentages express the distribution of responses from mathematics teachers by institution. I1 = Institution 1 (n=4); I2 = Institution 2 (n=2); I3 = Institution 3 (n=3); I4 = Institution 4 (n=6).

Use of teaching materials in mathematics

TABLE 4 *Frequency of use of teaching materials in mathematics by institution*

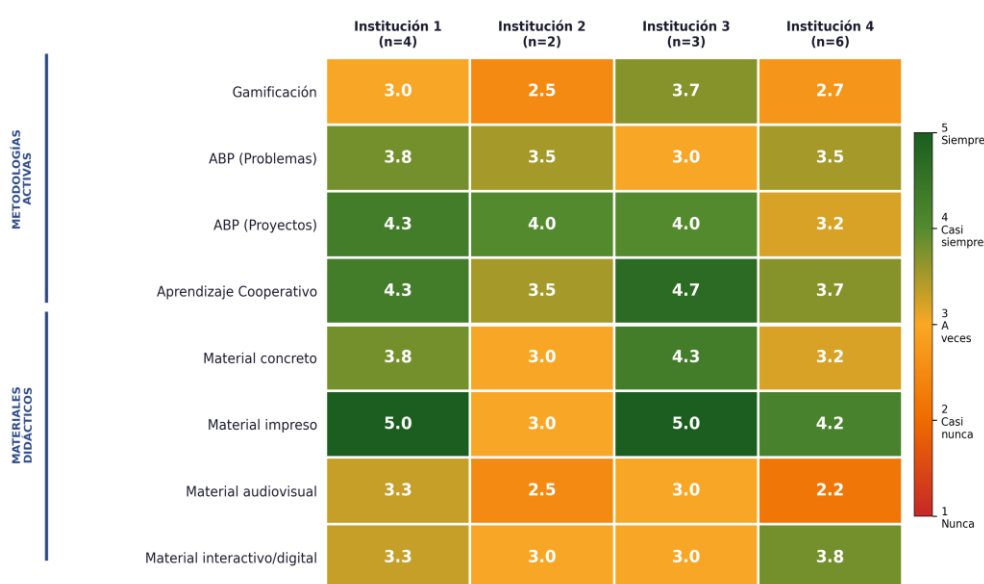
Institution	Almost never	Sometimes	Almost always	Always
Concrete material				
I1 (n=4)	0,0%	83,3%	16,7%	0,0%
I2 (n=2)	0,0%	100,0%	0,0%	0,0%
I3 (n=3)	0,0%	0,0%	66,7%	33,3%
I4 (n=6)	0,0%	83,3%	16,7%	0,0%
Printed material				
I1 (n=4)	0,0%	0,0%	50,0%	50,0%
I2 (n=2)	0,0%	16,7%	50,0%	33,3%
I3 (n=3)	0,0%	0,0%	0,0%	100,0%
I4 (n=6)	0,0%	16,7%	50,0%	33,3%
Audiovisual material				
I1 (n=4)	0,0%	75,0%	0,0%	25,0%
I2 (n=2)	50,0%	50,0%	0,0%	0,0%
I3 (n=3)	0,0%	100,0%	0,0%	0,0%
I4 (n=6)	83,3%	0,0%	16,7%	0,0%
Interactive/digital material				
I1 (n=4)	50,0%	0,0%	25,0%	25,0%
I2 (n=2)	0,0%	100,0%	0,0%	0,0%
I3 (n=3)	33,3%	33,3%	33,3%	0,0%
I4 (n=6)	16,7%	33,3%	50,0%	0,0%

Note: The percentages express the distribution of responses from mathematics teachers by institution. I1 = Institution 1 (n=4); I2 = Institution 2 (n=2); I3 = Institution 3 (n=3); I4 = Institution 4 (n=6).

As for teaching materials (Table 3), concrete material is sometimes used mainly in Institutions 2, 3 and 4, while in Institution 1 16.7% use it almost always. Printed material is the most consolidated resource in all institutions: in Institution 3 100% of the teachers always use it, and in Institution 1 50% almost always and 50% always. Institutions 2 and 4 use it less regularly, with the category sometimes predominating. Audiovisual material has the lowest pattern of

use of all the types evaluated: in Institution 4, 83.3% almost never use it; in Institution 2 50% almost never and 50% sometimes. Interactive or digital material shows the greatest heterogeneity: in Institution 4 50% use it almost always, while in Institution 2 100% use it only sometimes. In Institutions 1 and 3, the use varies between almost never and almost always depending on the teacher.

FIGURE 1 Heat map of the teacher diagnosis: intensity of use of active methodologies and teaching materials by institution (weighted average Likert scale 1–5)



Note: Dark green = high frequency (≥ 4.5); light green = moderate-high frequency (3.5–4.4); yellow = moderate frequency (3.0–3.4); orange-red = low frequency (< 3.0).

In summary, the diagnosis reveals that the teaching staff of the four institutions has an active methodological repertoire, although of irregular application. As Figure 1 shows, cooperative learning and project-based PBL are the most consolidated strategies in everyday teaching practice, while gamification and problem-based PBL are used more sporadically. In terms of resources, printed material maintains a dominant position, while audiovisual and interactive materials remain underutilized. This gap between the available repertoire and its systematic application was the main need identified and the starting point for designing the

intervention.

Academic performance in mathematics: pre-post intervention comparison

The second specific objective was to compare performance in mathematics before and after the intervention. The official grade point averages (0–10 scale) of 679 students were analyzed using a two-phase protocol.

Verification of data distribution

Since all samples exceeded 50 students, the Kolmogorov-Smirnov test was used to verify normality ($\alpha = 0.05$).

TABLE 5 *Tests of Normality of Math Grades by Institution*

Institution	n	Applied test	P before	p later	Distribution	Test used
Institution 1	148	Kolmogorov-Smirnov	0,003	0,041	No normal	Wilcoxon
Institution 2	142	Kolmogorov-Smirnov	0,000	0,002	No normal	Wilcoxon
Institution 3	156	Kolmogorov-Smirnov	0,012	0,038	No normal	Wilcoxon
Institution 4	233	Kolmogorov-Smirnov	0,028	0,200*	No normal	Wilcoxon

Note: *In Institution 4, subsequent scores were $p = 0.200$ (normal distribution); however, since previous scores were nonparametric, Wilcoxon was applied to both measures to maintain methodological consistency. n total = 679.

In all institutions, at least one of the two distributions (before or after) was not normal, which led to the use of Wilcoxon's nonparametric test for related samples as the main statistical contrast. This procedure is appropriate for repeated measures designs in which the assumptions of normality are not generally met (Gray, 2023).

Comparison of pre- and post-intervention means

Table 5 summarizes Wilcoxon's descriptive

statistics and results. In all four cases, the p-value was 0.000, which allows us to reject H_0 with 95% confidence and conclude that the grades improved statistically significantly after the intervention. The average gain was 0.57 points, with a variation between 0.47 points in Institution 2 and 0.64 in Institution 1. Although significant, the magnitude of the improvement is moderately *expected in interventions of an academic semester in real classroom contexts (Campbell & Stanley, 1963)*.

TABLE 6 *Descriptive Statistics and Wilcoxon Test Results by Institution (Mathematics)*

Institution	n	Average before	Media after	Difference (Δ)	Z (Wilcoxon)	p-value
Institution 1	148	7,08	7,72	+0,64	-5,814	0,0001
Institution 2	142	7,13	7,60	+0,47	-3,755	0,0001
Institution 3	156	7,31	7,94	+0,63	-6,103	0,0001
Institution 4	233	7,22	7,78	+0,56	-6,183	0,0001
Total/Average	679	7,19	7,76	+0,57	—	<0.001

Source: Own elaboration

Institution 3 achieved the highest subsequent

mean of the group (7.94), a result consistent with

the more consolidated teaching profile recorded in the previous diagnosis. Institution 2 obtained the lowest gain ($\Delta = 0.47$), a result that can be associated with the small number of participating teachers ($n = 2$) and the more irregular implementation of active methodologies evidenced in the diagnostic phase. Institution 4, with the largest sample ($n = 233$) and the highest Z statistic in absolute value (-6.183), confirms the robustness of the effect of the intervention even with high sample sizes.

Level of satisfaction with active methodologies and teaching materials

The third objective sought to determine the level of satisfaction of teachers and students with the intervention. A Likert survey was applied at the

end of the intervention: to the 20 teachers and 679 students. The results are expressed as percentage of responses 'satisfied' and 'very satisfied'.

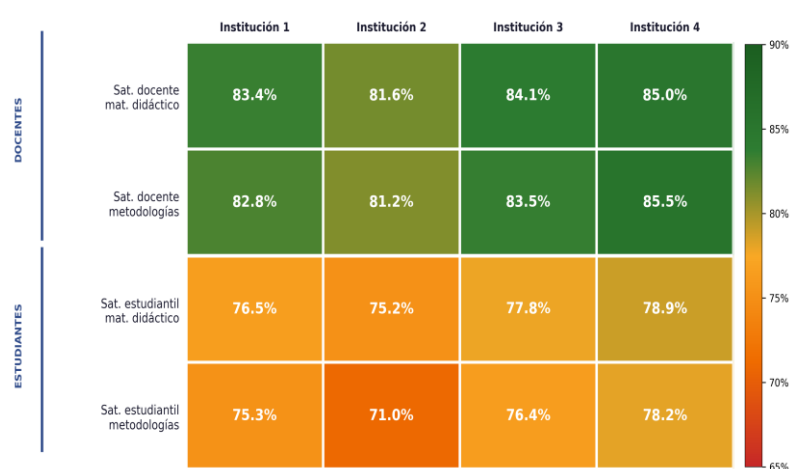
Teachers reported high levels in both dimensions. According to Table 6, satisfaction with the teaching material ranged from 81.6% in Institution 2 to 85.0% in Institution 4; satisfaction with the methodologies, between 81.2% and 85.5% at the same extremes. In practical terms, more than four out of five teachers positively valued the resources and strategies used. Institution 4, with the most systematic implementation, led the indices; Institution 2 obtained the lowest results.

TABLE 7 *Level of satisfaction of teachers and students by institution (% of responses 'satisfied' and 'very satisfied')*

Institution	Sat. docente mat. didactic	Teaching methodologies	Sat. estudiante mat. didactic	Student methodologies
Institution 1	83,40%	82,80%	76,50%	75,30%
Institution 2	81,60%	81,20%	75,16%	70,98%
Institution 3	84,10%	83,50%	77,80%	76,40%
Institution 4	85,00%	85,50%	78,92%	78,17%

Source: Own elaboration

FIGURE 2 *Heat map of the level of teacher and student satisfaction by institution (% positive responses)*



Note: Green = high satisfaction ($>82\%$); yellow-orange = moderate satisfaction ($70-79\%$). Teachers: $n=20$; Students: $n=679$.

Among the students, the levels of satisfaction were positive, but systematically lower than those of the teachers. Satisfaction with the teaching material was the best scored dimension (75.16%–78.92%); satisfaction with the methodologies was slightly lower (70.98%–78.17%). The most pronounced gap was observed in Institution 2, where 30% expressed dissatisfaction with pedagogical strategies, a result consistent with their lower academic gain ($\Delta = 0.47$). Institution 3 and Institution 4, on the other hand, presented the most balanced and elevated profiles of the whole.

In line with the literature, the data confirm that gamification, PBL and cooperative learning generate positive affective responses when applied in a planned way and with appropriate materials. However, the percentages below 80%

in some institutions suggest that the quality of implementation operates as a critical moderating variable.

At the institutional level, there is also a positive correlation between satisfaction and performance: the institutions with the highest satisfaction rates also registered the highest academic gains, while Institution 2 occupied the last positions in both variables.

Relationship between satisfaction and improvement in academic performance

To explore the relationship between student satisfaction and improvement in performance, Table 7 is presented, with the data used in this analysis:

TABLE 7 *Average student satisfaction and achievement gain by institution*

Institution	Sat. mat. didactic (%)	Sat. methodologies (%)	Sat. media (%)	Gain Δ (points)
Institution 1	76,50	75,30	75,90	+0,64
Institution 2	75,16	70,98	73,07	+0,47
Institution 3	77,80	76,40	77,10	+0,63
Institution 4	78,92	78,17	78,55	+0,56

Note: Sat. mean = average satisfaction with teaching material and methodologies. Δ = gain in performance (subsequent mean – previous mean).

At the descriptive level, a consistent positive trend is observed: Institution 2, with the lowest average student satisfaction (73.07%), also registered the lowest academic gain ($\Delta = 0.47$); Institution 1, with an average satisfaction of 75.90%, achieved the highest gain ($\Delta = 0.64$); and Institution 4, with the highest satisfaction (78.55%), obtained a gain of 0.56 points.

Discussion

The results confirm the H_1 hypothesis: the combined implementation of gamification, PBL and cooperative learning, supported by diversified teaching materials, produced statistically significant improvements in mathematical performance in the four institutions ($p = 0.000$), with a mean gain of 0.57 points on a scale of 10. This finding coincides

with what was reported by Talkhan et al. (2025), whose meta-analysis, with a pooled Hedges' effect size $g = 0.71$, 95% CI [0.60–0.82], concludes that cooperative learning produces moderate-to-high improvements in mathematics performance, especially when combined with specific resources and cognitively demanding tasks, conditions that characterized the design of this intervention.

Cooperative learning was the methodology with

the greatest consolidated presence and the most consistent pattern of improvement among institutions. Mendo-Lázaro et al. (2022), in a quasi-experimental design with 509 students, demonstrated that this strategy significantly improves academic achievement goals ($F = 67.338$; $p < 0.001$; $\eta^2 = 0.141$), increasing commitment and persistence in the face of difficulty. Although its sample is university, the mechanism of positive interdependence and individual responsibility works in an analogous way in high school (Johnson & Johnson, 1999, cited in Mendo-Lázaro et al., 2022). In addition, Ssali et al. (2025), in their systematic review of 56 articles, identified as conditions for effective implementation of PBL in secondary school the explicit planning of the sequence of problems, the facilitating role of the teacher, and the availability of support materials; The three elements were present in the intervention reported here.

The study has, however, limitations that should be pointed out transparently. The quasi-experimental design without a control group does not rule out threats to internal validity such as maturation or regression to the mean (Campbell and Stanley, 1963). The heterogeneity in the number of teachers per institution *from 2 to 6* introduced variability in the fidelity of the implementation and partly explains the inter-institutional differences observed. Future studies should incorporate comparison groups, balanced samples between institutions, and longitudinal follow-up to evaluate the persistence of the effects, as well as analyze the differential impact of each active methodology separately, an aspect that is still little explored in the Ecuadorian and Latin American educational literature.

Conclusions

This research evaluated the impact of implementing gamification, Problem-Based Learning (PBL), Project-Based Learning and cooperative learning, along with diversified didactic materials, on academic performance and satisfaction in mathematics, in four secondary and high school institutions in southern Ecuador. Based on the results obtained and the

discussion developed, the following conclusions are formulated.

The initial diagnosis revealed that the teaching staff had an active methodological repertoire, but its application was irregular. Cooperative learning and project-based PBL were the most consolidated strategies, while gamification and problem-based PBL were used sporadically. Printed material predominated over audiovisual and interactive resources, whose use was limited by technological barriers and insufficient continuous training.

The intervention produced statistically significant improvements in performance at all four institutions (Wilcoxon, $p = 0.000$), with a mean gain of 0.57 points on a scale of 10 *with variations between 0.47 and 0.64 depending on the institution*. These results allow us to accept the hypothesis and confirm that active methodologies, when applied in a combined and planned manner, constitute an effective strategy to strengthen the learning of mathematics in Ecuadorian secondary education.

The levels of teacher and student satisfaction with the methodologies and materials implemented were positive in all institutions. On average, 83.0% of teachers and 75.5% of students expressed favorable evaluations. The systematic gap of approximately 7 points between the two groups reflects that students apply more demanding criteria when evaluating their learning experience, probably based on the perceived usefulness and the effort that each methodology demanded. *approximately 7 percentage points* suggests that students apply more demanding criteria of perceived usefulness and effort required when evaluating learning experiences.

The inter-institutional variability observed indicates that the fidelity of the implementation and the availability of technological resources are moderating variables of the first order. Institutions with greater previous use of active methodologies were favored after the intervention, which underscores the need for continuous teacher training as an indispensable condition for this type of pedagogical initiatives

to achieve the expected impact *on both performance and satisfaction*. Institutions with a higher frequency of using active methodologies in the previous diagnosis obtained more favorable results after the intervention, which underscores the importance of continuous teacher training and the availability of technological resources as enabling conditions for the success of this type of pedagogical interventions.

In broader terms, the findings have direct implications for the design of university linkage

programs in Latin American contexts: it is possible to generate significant improvements in performance and satisfaction in mathematics with accessible resources and in relatively short periods, as long as the intervention is planned, progressive, and preceded by a contextual diagnosis.

Note

¹ From now on, the masculine will be used in this work with the sole objective of making more fluid reading, without detriment to gender.

References

- Ayari, Mohamed; Sellami, Abdellatif; Santhosh, Malavika; Naji, Khalid; Al-Ali, Abdula y Al-Hazbi, Saleh (2025). "From problems to performance: a systematic review of PBL in K-12 mathematics", *Frontiers in Education*, vol. 10, art. 1731307. <https://doi.org/10.3389/educ.2025.1731307>
- Camacho-Morles, Julio; Slem, Gavin; Pekrun, Reinhard; Loderes, Hanchao y Oades, Lindsay (2021). "Activity achievement emotions and academic performance: A meta-analysis", *Educational Psychology Review*, vol. 33, núm. 3, pp. 1051-1095. <https://doi.org/10.1007/s10648-020-09585-3>
- Campbell, Donald y Stanley, Julian (1963). *Experimental and Quasi-Experimental Designs for Research*, Chicago: Rand McNally.
- Rezio, Sofia; Andrade, Marina; Teodoro, María (2022). "Problem-based learning and applied mathematics", *Mathematics*, vol. 10, núm. 16, art. 2862. <https://doi.org/10.3390/math10162862>
- Cordero, Jorge; Torres-Zambrano, Jonathan; Cordero-Castillo, Alison (2025). "Integrating Generative Artificial Intelligence in Higher Education: Best Practices", *Education Sciences*, Vol. 15, No. 1, Art. 32. <https://doi.org/10.3390/educsci15010032>
- Espinosa-Pinos, Carlos; Mazaquiza-Paucar, Alex y Sánchez-Benítez, Clara (2024). "The use of gamification in mathematics education: Enhancing Geometry Comprehension with High School Students", *Lecture Notes in Computer Science*, vol. 14723, pp. 17-30. https://doi.org/10.1007/978-3-031-61685-3_2
- Fuentes-Riffo, Karina; Salcedo-Lagos, Pedro; Sanhueza-Campos, Cristian; Pinacho-Davidson, Pedro; Friz-Carrillo, Miguel; Kotz-Grabole, Gabriela y Espejo-Burkart, Fabiola (2023). "The influence of gamification on high school students' motivation in geometry lessons", *Sustainability*, vol. 15, núm. 21, art. 15615. <https://doi.org/10.3390/su152115615>
- Granello, Federica; Cuder, Alessandro; Doz, Eleonora; Pellizzoni, Sandra y Passolunghi, Maria (2025). "Improving math self-efficacy and math self-concept in middle school: a narrative systematic review", *European Journal of Psychology of Education*, vol. 40, art. 42. <https://doi.org/10.1007/s10212-025-00939-5>
- Gray, David (2023). *Doing Research in the Real World*, 5th ed., London: SAGE.
- Hui, Hii y Mahmud, Muhammad (2023). "Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review", *Frontiers in Psychology*, vol. 14, art. 1105806. <https://doi.org/10.3389/fpsyg.2023.1105806>
- Jaramillo-Mediavilla, Lorena; Basantes-Andrade, Andrea; Cabezas-González, Marcos y Casillas-Martín, Sonia (2024). "Impact of gamification on motivation and academic performance: A systematic review", *Education Sciences*, vol. 14, núm. 6, art. 639. <https://doi.org/10.3390/educsci14060639>
- Jiménez-Jaraba, María; Llorente-Cejudo, Carmen y Palacios-Rodríguez, Antonio (2025). "Validation of a Scale on University Teaching Quality in the Area of Mathematics", *Education Sciences*, vol. 15, núm. 4, art. 424. <https://doi.org/10.3390/educsci15040424>
- Kalogiannakis, Michail; Papadakis, Stamatios y Zourmpakis, Alkinoos (2021). "Gamification in science education: A systematic review of the literature", *Education Sciences*, vol. 11, núm. 1, art. 22. <https://doi.org/10.3390/educsci11010022>

- Kim, Jihoon y Castelli, Darla (2021). "Effects of gamification on behavioral change in education: A Meta-Analysis", *International Journal of Environmental Research and Public Health*, vol. 18, núm. 7, art. 3550. <https://doi.org/10.3390/ijerph18073550>
- Lo, Chung Kwan y Hew, Khe Foon (2020). "A comparison of flipped learning with gamification, traditional learning, and online independent study: the effects on students' mathematics achievement and cognitive engagement", *Interactive Learning Environments*, vol. 28, núm. 4, pp. 464-481. <https://doi.org/10.1080/10494820.2018.1541910>
- Mendo-Lázaro, Santiago; León-del-Barco, Benito; Polo-del-Río, María-Isabel y López-Ramos, Víctor (2022). "The impact of cooperative learning on university students' academic goals", *Frontiers in Psychology*, vol. 12, art. 787210. <https://doi.org/10.3389/fpsyg.2021.787210>
- Ramírez Ruiz, Judy; Vargas Sánchez, Ana y Boude Figueredo, Oscar (2024). "Impact of gamification on school engagement: A systematic review", *Frontiers in Education*, vol. 9, art. 1466926. <https://doi.org/10.3389/feduc.2024.1466926>
- Rehman, Nadia; Huang, Xiao; Mahmood, Amir; AlGerafi, Mohammed y Javed, Saima (2024). "Project-based learning as a catalyst for 21st-Century skills and student engagement in the math classroom", *Heliyon*, vol. 10, núm. 23, art. e39988. <https://doi.org/10.1016/j.heliyon.2024.e39988>
- Ruiz-Peralta, Karina & Reyes-Acaro, María (2025). "Didactic Strategies for the Teaching-Learning Process of Mathematics", *Revista Uniandes Episteme*, vol. 12, no. 2, pp. 255-276. <https://doi.org/10.61154/rue.v12i2.3699>
- Siller, Hans-Stefan y Ahmad, Sagheer (2024). "Analyzing the impact of collaborative learning approach on grade six students' mathematics achievement and attitude towards mathematics", *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 20, núm. 2, art. em2336. <https://doi.org/10.29333/ejmste/14153>
- Ssali, Celester; Kabuye Batiibwe, Marjorie; Dahl, Bettina; Ampeire Kariisa, Henry; Magero, Juan y Mayende, Godfrey (2025). "Problem-based learning in secondary school mathematics: a review", *Educational Research*, vol. 67, núm. 2, pp. 212-230. <https://doi.org/10.1080/00131881.2025.2493255>
- Talkhan, Eman; Alhubaidah, Shahad; Muthanna, Aisha y Qadhi, Saba (2025). "The effect of cooperative learning toward mathematics achievement of primary students: A systematic review using meta-analysis", *Social Sciences & Humanities Open*, vol. 12, art. 102247. <https://doi.org/10.1016/j.ssaho.2025.102247>
- Yuhana, Yuyu y Widi Fajari, Laksmi (2025). "Cross-disciplinary effects of problem-based learning on problem-solving skills in mathematics and beyond: A comprehensive meta-analysis and bibliometric", *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 21, núm. 11, art. em2732. <https://doi.org/10.29333/ejmste/17345>
- Zach, Sima; Shoval, Ella y Shulruf, Boaz (2023). "Cooperative learning in physical education lessons - literature review", *Frontiers in Education*, vol. 8, art. 1273423. <https://doi.org/10.3389/feduc.2023.1273423>
- Zakariya, Yusuf (2022). "Improving students' mathematics self-efficacy: A systematic review of intervention studies", *Frontiers in Psychology*, vol. 13, art. 986622. <https://doi.org/10.3389/fpsyg.2022.986622>
- Zeng, Jiyuan; Sun, Daner; Looi, Chee-Kit y Wai Fan, Andy (2024). "Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023", *British Journal of Educational Technology*, vol. 55, núm. 6, pp. 2478-2502. <https://doi.org/10.1111/bjet.13471>