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Problem-Based Learning for Finalizing Mathematics Enrichment Module in Junior High School: A Quasi-Experimental Study

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Abstract

This study investigates the influence of problem-based learning (PBL) on junior high school students' engagement, motivation, and academic performance, with the aim of finalizing a standardized mathematics enrichment module. A quasi-experimental design was employed with two randomly selected groups: the control group (n = 42) received traditional mathematics instruction, while the experimental group (n = 42) participated in PBL-based enrichment classes over eight weeks. Data collection utilized adopted and validated instruments and proceeded in three phases: pre-test, PBL implementation, and post-test, with strict adherence to the university's research ethics standards. Descriptive and inferential statistics were employed to address the study objectives. Findings reveal that students exposed to PBL demonstrated significant improvement in academic performance (p = .001, Cohen's d = 0.624), whereas the control group exhibited a significant decline (p = .001, Cohen's d = 0.800). The experimental group also reported high levels of engagement (M = 3.40) and motivation (M = 3.29), particularly in self-regulation and utility value. Pearson's correlation analysis indicated a moderate positive relationship between engagement and motivation (r = 0.477, p = .001) and a weak but significant relationship between motivation and academic performance (r = 0.313, p = .044). These findings underscore the potential of PBL not only to improve academic outcomes but also to enhance motivation and engagement—critical affective components that support sustained learning. The results provide an evidence base for finalizing enrichment modules that incorporate authentic problem-solving, collaborative learning, and reflective activities. Embedding these features into standardized enrichment materials can help foster resilient, motivated, and high-performing mathematics learners in junior high school.

Keywords: *mathematics enrichment module, problem-based learning, quasi-experimental*

Introduction

Mathematics is integral to modern life, informing financial decisions, engineering design, technological innovation, and everyday problem-solving (Robinos, 2017; Robinos et al. 2021). Despite its importance, Filipino learners continue to struggle in mathematics. Students' anxiety in the subject has been increasingly recognized as a widespread problem across educational settings (Robinos et al., 2020). International large-scale assessments, such as PISA, reveal persistent gaps in numeracy and its applications (Servallos, 2023). In response, the Department of Education (DepEd) has implemented enrichment programs designed to foster higher-order thinking skills, prepare students for competitions, and support advanced study. Within this context, this study is situated in a junior high school enrichment program at the University of Perpetual Help System DALTA–Molino. Specifically, it examines whether problem-based learning (PBL)—a student-centered approach structured around authentic learning tasks—can enhance students' engagement, motivation, and academic performance, while also contributing to the standardization of enrichment modules.

PBL is widely acknowledged for promoting self-directed inquiry, collaboration, and real-world problem-solving (Meylani, 2024; Boom-Carcamo et al., 2024). Yet, much of the existing research in the Philippines has primarily focused on regular classroom settings, with greater emphasis on achievement outcomes rather than holistic factors such as engagement and motivation. This reveals a critical gap in understanding how PBL influences junior high school learners' multidimensional engagement (behavioral, emotional, and cognitive) and their motivation in the enrichment class context. Addressing this gap is particularly timely in the face of post-pandemic learning losses and the urgent demand for evidence-based enrichment pedagogy. By investigating these dimensions, this study seeks to generate insights that can strengthen the development of standardized enrichment modules in mathematics, ensuring that advanced learning opportunities remain both effective and responsive to the needs of 21st-century learners.

Investigating PBL in enrichment classes holds both theoretical and practical significance (Lapuz et al., 2020). Theoretically, it contributes to the growing body of literature on student-centered learning, engagement, and motivation—domains where empirical evidence in Southeast Asia remains relatively limited. Practically, it informs curriculum design and supports the development of standardized enrichment modules that cultivate both cognitive and non-cognitive skills, thereby sustaining participation, perseverance, and real-world application (Usman et al., 2024). In this regard, research on PBL provides valuable insights into how such approaches can elevate the quality of enrichment programs.

Evidence consistently supports PBL's effectiveness in mathematics education. Studies report significant gains in conceptual understanding, problem-solving, and higher-order thinking skills, with PBL students often outperforming peers in traditional classrooms (Meylani, 2024; Boom-Carcamo et al., 2024; Maquiling, 2023). Quasi-experimental findings highlight improvements in achievement and critical thinking (Usman et al., 2024; Lapuz et al., 2020), though such outcomes are contingent upon teachers' implementation expertise (Arbo & Ching, 2022). Furthermore, PBL scaffolds learners' transition from situational to formal understanding when combined with literacy and numeracy supports (Fauziyah, 2023). Complementing these findings, systematic reviews indicate that PBL fosters group learning, self-directed study, and positive attitudes toward mathematics across Southeast Asia (Chai et al., 2022; Prastiti et al., 2020).

Beyond achievement, motivation is a crucial factor in sustaining engagement. PBL situates mathematics in meaningful, real-world contexts, which enhances learners' autonomy, relevance, and intrinsic interest (Rizki et al., 2023; Purwanto et al., 2022). Classroom action research demonstrates increased motivation and mastery after structured PBL cycles (Ernawati et al., 2022), while larger-scale studies reveal improved confidence, perceived value of mathematics, and enjoyment, particularly when PBL is integrated with technology or flipped classroom designs (Zamir et al., 2022; Harrison, 2023). Learner-centered PBL environments further strengthen behavioral, emotional, and cognitive engagement (Mutonyi & Morrison, 2022), with no systematic gender differences observed (Hossein-Mohand & Hossein-Mohand, 2022).

Engagement research reinforces these outcomes, showing that PBL deepens participation, collaboration, and problem-solving, especially when combined with digital tools (Tleubekova et al., 2023; Llorente & Tado, 2024; Weng et al., 2023). Case studies highlight notable improvements in critical thinking and peer-to-peer inquiry (Ostby, 2022; Manalaysay, 2024), while meta-analyses consistently link engagement to higher achievement, emphasizing the central role of instructional design (García-Feijoo et al., 2022; Fredricks & Simpkins, 2023). Taken together, these findings underscore the multifaceted benefits of PBL, not only in raising performance but also in fostering motivation and engagement—key dimensions for the success of enrichment programs in mathematics.

Research on module development suggests that PBL-based instructional materials enhance metacognition, reasoning, and critical thinking when iteratively designed to address local needs (Le et al., 2022; Magpantay & Pasia, 2022; Sulatra, 2022). Evidence from Asian classrooms further indicates that PBL fosters both cognitive and behavioral engagement, supporting learner resilience and reinforcing its appropriateness for standardized enrichment modules (Tan & Lee, 2023; Abdulwahab et al., 2023). Expanding access to enrichment and extended learning programs is therefore vital, as these opportunities deepen learning, strengthen competencies, and provide students with a strong foundation for long-term success (Robinos et al., 2020).

Building on this foundation, the present study investigates the influence of PBL on junior high school students' engagement, motivation, and academic performance in mathematics enrichment classes, while also exploring implications for standardized module development. Specifically, it aims to:

1. Compare the first-quarter and second-quarter average grades between the control group

(traditional instruction) and the experimental group (PBL-based instruction);

2. Determine levels of engagement (behavioral, emotional, cognitive) and motivation (intrinsic value, self-regulation, self-efficacy, utility value, test anxiety);
3. Examine differences in academic performances
4. Investigate the relationships among engagement, motivation, and academic performance.

Methodology

This study employed a quasi-experimental descriptive research design to investigate the effects of problem-based learning (PBL) on junior high school students' engagement, motivation, and academic performance in mathematics enrichment classes. Quantitative data were collected on students' demographic profiles (age, sex, grade level), first- and second-quarter mathematics average grades, and survey responses on engagement and motivation. The design enabled comparison between an experimental group exposed to PBL and a control group receiving traditional instruction, with correlation and regression analyses used to explore predictive relationships and inform enrichment module development.

The study was conducted at the University of Perpetual Help System DALTA–Molino Campus during SY 2024–2025. Participants were selected through stratified random sampling across Grades 7 to 10. The sample consisted of 84 students, divided into an experimental group (n = 42) enrolled in the mathematics enrichment class and a control group (n = 42) in regular mathematics classes. The sample size was determined using formulas for comparing two means. Random assignment was conducted using the *Wheel of Names* app.

The PBL intervention was implemented over eight weeks during the second quarter in the enrichment class program, which was scheduled weekly every Tuesday from 4:00–5:00 p.m. The control group continued with traditional instruction. This structured academic setting provided consistent delivery of instruction and standardized assessment, ensuring reliable evaluation of PBL's effects on learning outcomes.

Data collection relied on adopted and validated instruments:

- Engagement: A 4-point Likert scale survey adapted from Kassab et al. (2023), measuring emotional, cognitive, and behavioral engagement.
- Motivation: The Mathematics Motivation Questionnaire (MMQ) by Fiorella et al. (2021), covering intrinsic value, self-efficacy, utility value, test anxiety, and self-regulation.
- Academic Performance: Students' first- and second-quarter average grades obtained from official school records, based on the DepEd K–12 grading system.

Data collection proceeded in three phases:

1. **Pre-test phase:** First-quarter grades were obtained for both groups.
2. **Intervention phase:** The experimental group underwent eight weeks of PBL-based instruction, while the control group continued with traditional methods.
3. **Post-test phase:** Second-quarter grades were collected to assess changes in academic performance, while engagement and motivation were measured using secure Google Forms. Only students with signed consent/assent participated. Data were anonymized and securely stored.

The study strictly adhered to ethical standards. Participation was voluntary, with the right to withdraw at any time without penalty. Informed consent and assent forms were administered by the guidance counselor in both English and Tagalog to avoid undue influence. No incentives were provided, and all activities were free of charge. Confidentiality was maintained in compliance with RA 10173 (Data Privacy Act of 2012). Participants were assigned unique codes; electronic data were stored in encrypted password-protected files, and hard copies were secured in locked cabinets. Data will be retained for five years before permanent destruction. Results will be disseminated through aggregate reporting, with summaries shared with participating institutions and families.

Both descriptive and inferential statistics were employed. Means and standard deviations described levels of engagement, motivation, and academic performance. Independent sample t-tests compared experimental and control groups, while paired sample t-tests assessed within-group changes. One-way ANOVA with Tukey HSD tested differences across demographics. Effect sizes were calculated using Cohen's d, correlations were analyzed using Pearson's r, and multiple regression identified motivational factors predicting engagement and academic performance. All analyses were conducted using *Jamovi 2.6.44*.

Results and Discussions

Before conducting inferential analyses, preliminary assumption testing was performed. The assumptions of normality and homogeneity of variances were examined to ensure the appropriateness of parametric tests. The Shapiro–Wilk test was applied to assess normal distribution, while Levene's test evaluated homogeneity of variances. Results indicated that the assumptions were largely satisfied ($p > 0.05$), justifying the use of parametric procedures. An exception was noted in the engagement scores of students aged 14–15 years ($p = 0.027$), for which a non-parametric alternative, the Kruskal–Wallis test, was employed.

Comparison of the Academic Performance

Table 1. Academic Performance before and after PBL implementation

	Control Group		**Experimental Group**	
	Mean Score	Description	Mean Score	Description
Before (1st Quarter)	85	Very Satisfactory	89	Very Satisfactory
After (2nd Quarter)	84	Satisfactory	90	Outstanding

Note: Grades Description follows DepEd Order No. 8 s. 2015. N=42 per group

Academic performance prior to the implementation of PBL was measured using students' first-quarter average grades. The control group obtained a mean score of 85, classified as *Very Satisfactory*, while the experimental group recorded a slightly higher mean of 89, also classified as *Very Satisfactory*. After the implementation of PBL in the second quarter, the control group's mean slightly declined to 84, categorized as *Satisfactory*, whereas the experimental group's mean increased to 90, reaching the *Outstanding* level. These results suggest that PBL contributed to improved academic performance compared with traditional instruction. The observed improvement in the experimental group aligns with existing literature on the effectiveness of PBL in mathematics education. Meylani (2024) reported that PBL enhances both student achievement and critical thinking, while Usman et al. (2024) found that learners taught through PBL significantly outperformed those in conventional settings. Similarly, Boom-Carcamo et al. (2024) confirmed that PBL contributes to significant gains in mathematics achievement. Taken together, these findings reinforce the present study's results, highlighting the value of PBL in promoting higher levels of academic performance.

Levels of Engagement and Motivation of Students Exposed to PBL

Table 2. Level of Engagement towards the Mathematics Enrichment Class Program

Student Engagement in PBL	**Mean**	**Interpretation**
Emotional domain	3.39	Highly engaged
Cognitive domain	3.40	Highly engaged
Behavioral domain	3.40	Highly engaged
Overall Mean	***3.39***	***Highly engaged***

Interpretation: Highly Engaged 3.26-4.00, Moderately Engaged 2.51-3.25, Slightly Engaged 1.76-2.50, Not Engaged 1.00-1.75

The level of engagement of students exposed to PBL shows an overall mean of 3.39, interpreted as *Highly Engaged*. In the emotional domain, students reported that they enjoyed PBL tutorials and found activities interesting, while the item *"I wish I could continue for a while"* was rated moderately. Cognitive engagement yielded an average of 3.40, reflecting consistent effort in understanding concepts, the ability to maintain focus, and the application of deep learning strategies. Behavioral engagement also averaged 3.40, with punctuality, task completion, and participation serving as its main indicators.

Taken together, the high levels of emotional, cognitive, and behavioral engagement suggest that the PBL approach effectively captures students' interest, stimulates deeper cognitive involvement, and encourages active participation in the mathematics enrichment class. These findings are consistent with prior research, which emphasizes that PBL environments enhance student engagement and foster deeper learning involvement (Tleubekova et al., 2023). Similarly, Ostby (2022) observed that PBL strengthens collaborative engagement, as teamwork allows students to learn through shared inquiry. Manalaysay (2024) further concluded that PBL activities engage learners in mathematical investigations, enabling them to solve problems more meaningfully. The present results therefore reinforce the literature, affirming PBL's role in promoting holistic student engagement in mathematics.

Table 3. Level of Motivation towards the Mathematics Enrichment Class Program

Indicators Using the Mathematics Motivation Questionnaire (MMQ)	Mean	Interpretation
Intrinsic Value	3.05	Moderate
Self-regulation	3.41	High
Self-efficacy	2.95	Moderate
Utility Value	3.49	High
Test Anxiety	3.44	High
Overall Mean	***3.29***	***Highly motivated***

Interpretation: Highly Motivated 3.26-4.00, Moderately Motivated 2.51-3.25, Slightly Motivated 1.76-2.50, Not Motivated 1.00-1.75

The overall motivation level of students was classified as *Highly Motivated* (M = 3.29). Within the subscales, intrinsic value was rated as *Moderately Motivated* (M = 3.05), as students showed interest in mathematics but only moderate enjoyment when solving challenging problems. Self-regulation obtained the highest rating (M = 3.41), demonstrating students' strong study habits, effort, and preparation strategies. Self-efficacy was lower, falling within the moderate range (M = 2.95). The highest score across all domains was observed in utility value (M = 3.49), indicating that students recognized the practical importance of learning mathematics. Test anxiety was also notable (M = 3.44), while concerns about peer comparison were rated relatively lower.

The results indicate that the use of PBL effectively fostered higher levels of motivation, particularly in self-regulation, utility value, and resilience despite test anxiety. These findings reinforce the role of PBL in promoting learner autonomy, relevance, and self-directed learning (Rizki et al., 2023; Purwanto et al., 2022). By situating learning within real-world problem contexts, PBL enables students to appreciate the usefulness of mathematics beyond the classroom, thereby strengthening their motivation. However, the moderate scores in intrinsic value and self-efficacy suggest areas where further intervention is needed, such as designing tasks that gradually build students' confidence and intrinsic enjoyment of problem-solving. This outcome is consistent with Zamir et al. (2022), who found that PBL significantly enhances students' confidence in learning mathematics, their perceived value of the subject, and their overall motivation. Thus, the present study substantiates prior evidence that PBL not only enhances performance but also cultivates motivation, making it a powerful approach for sustaining student engagement in mathematics.

Differences in Academic Performance before and after PBL Implementation

Table 4. Paired Sample t-Test: First and Second Quarter Grades

	Quarter	Mean	SD	t value	df	p-value	Cohen's d	Interpretation
Control Group	First	84.9	3.26	5.18	41	.0001	0.800	Significant
	Second	83.7	3.30					
Experimental Group	First	88.5	4.25	-4.04	41	.0001	0.624	Significant
	Second	90.1	4.38					

Note: The result is significant at p<.05. SD – Standard Deviation; N=84

Paired-sample t-tests revealed a significant difference in academic performance across quarters. The control group's average grades declined from 84.9 to 83.7 (p < 0.001, Cohen's d = 0.080), indicating a negligible effect size despite being statistically significant. This decline suggests that traditional instruction alone may not be sufficient to sustain students' performance over time. As Le et al. (2022) emphasized, continuous instructional support and adaptive teaching strategies are necessary to prevent learning loss and to maintain steady academic achievement.

In contrast, the experimental group demonstrated significant improvement, with mean grades increasing from 88.5 to 90.1 (p < 0.001, Cohen's d = 0.624), reflecting a medium to large effect size. This result indicates that the integration of PBL created meaningful academic gains. The improvement supports Maquiling (2023), who affirmed that student-centered instructional approaches foster deeper learning and enhance performance by engaging learners in active, inquiry-driven tasks.

Between-group analysis further highlighted the advantages of PBL. While the experimental group gained an average of 1.38 points, the control group lost 1.43 points, with the difference being statistically significant ($p < 0.001$, Cohen's d = 1.26). This large effect strongly favors the experimental group, underscoring the effectiveness of PBL in sustaining and improving academic outcomes. Such findings are consistent with global evidence showing that PBL not only improves test scores but also promotes critical thinking, problem-solving, and transfer of learning.

Table 5. Independent Sample t-Test: Change in grades between the two groups

	Mean Change	SD	t value	df	p-value	Cohen's d	Interpretation
Experimental	1.38	2.45	5.77	82	<.001	1.26	Significant
Control	-1.43	1.99					

Note: The result is significant at p<.05. Mean Change = 2nd Quarter -1st Quarter Grades

Further analyses examined differences in engagement and motivation across demographic variables. Results showed no significant differences in engagement by sex ($p = 0.568$), grade level ($p = 0.525$), or age ($p = 0.953$). Effect sizes were negligible, indicating that the PBL approach consistently promotes engagement across diverse student groups. Interestingly, a significant difference in motivation was observed across grade levels ($p = 0.042$). Post-hoc comparisons revealed that Grade 8 students reported higher motivation compared to other grade levels, suggesting that students at this stage may be more responsive to PBL due to their developmental readiness and growing curiosity about abstract concepts. However, no significant differences in motivation were found by sex ($p = 0.388$) or age ($p = 0.982$), implying that the motivational benefits of PBL extend broadly across demographics.

These findings highlight that PBL has a considerable influence on students' engagement and motivation, regardless of personal characteristics, while offering particular benefits for Grade 8 learners. This consistency reinforces the value of PBL as an inclusive instructional strategy that supports a wide range of learners. More importantly, the observed increase in motivation aligns with its documented impact on academic achievement. Le et al. (2022) emphasized that PBL significantly improves academic performance compared to traditional methods by engaging students in active, real-world problem solving. Similarly, Fauziyah (2023) reported that PBL combined with literacy and numeracy initiatives helps learners progress from basic comprehension toward higher-order application of mathematical concepts. Chai et al. (2022) further noted that PBL not only enhances academic proficiency but also deepens conceptual understanding, fosters social interaction and collaboration, promotes self-directed learning, and improves students' overall attitudes toward mathematics.

Taken together, the findings suggest that adopting PBL in mathematics enrichment programs can build both cognitive and affective dimensions of learning. By fostering engagement and motivation across diverse groups, schools can enhance inclusivity while simultaneously strengthening academic performance and preparing students for lifelong learning.

Relationship among engagement, motivation and academic performance

Table 5. Pearson r correlation test among variables

	R-value	p-value	Interpretation
Engagement and Motivation	0.477	.001	Low Correlation ***Significant***
Engagement and Average Grades	0.143	.366	***Not significant***
Motivation and Average Grades	0.313	.044	Low Correlation ***Significant***

Note: The result is significant at p<.05. n = 42, *df* = degrees of freedom= 40

Correlation analysis was conducted to examine the relationships among engagement, motivation, and academic performance. Results revealed a significant but low positive correlation between engagement and motivation ($r = 0.477$, $p = 0.001$). This finding supports Mutonyi and Morrison (2022), who explained that engagement is directly proportional to motivation: when students are actively engaged cognitively, emotionally, and behaviorally, they are more likely to develop higher intrinsic motivation. This dynamic is particularly evident in PBL contexts, where collaborative learning, problem exploration, and learner autonomy foster both engagement and motivation simultaneously.

In contrast, the relationship between engagement and grades was negligible and non-significant ($r = 0.143$, $p = 0.366$). This aligns with Garcia-Feijo et al. (2022), who reported that while engagement is often linked to achievement, its effects can vary depending on how engagement is measured and the context in which learning occurs. Engagement is a multidimensional construct, and increased participation in meaningful learning activities may not always translate directly into higher grades. In the present study, PBL may have enhanced students' involvement and interest in mathematics without producing a proportional increase in academic performance within the limited timeframe of the intervention.

Motivation, however, showed a weak but significant positive correlation with grades ($r = 0.313$, $p = 0.044$). This supports the findings of Zhen et al. (2022), who emphasized that while motivation alone does not guarantee academic achievement, it is an important predictor of positive learning behaviors. Motivated students are more likely to use deep learning strategies, persist in challenging tasks, and take ownership of their academic responsibilities. Although these behaviors may not immediately yield high grades, they contribute to gradual and sustainable improvement in performance. Within the framework of PBL, strategies that nurture student autonomy, highlight real-world relevance, and reduce test anxiety can strengthen motivation, which in turn supports long-term academic growth.

Overall, these correlations suggest that PBL has a stronger immediate impact on students' engagement and motivation than on academic grades. Nevertheless, by reinforcing intrinsic motivation and active participation, PBL lays the groundwork for deeper learning and improved achievement over time.

Conclusion and recommendations

This study confirms the effectiveness of Problem-Based Learning (PBL) in enhancing academic performance, engagement, and motivation in secondary mathematics. Students exposed to PBL achieved higher grades, reflecting deeper conceptual understanding, stronger critical thinking, and improved problem-solving skills compared to traditional instruction. Engagement was consistently high across cognitive, emotional, and behavioral domains, while motivation was strongest in utility value and self-regulation. Moderate scores in intrinsic value and self-efficacy, however, point to the need for strategies that build enjoyment and confidence in mathematics. Motivation showed a modest but significant link to academic performance, underscoring its central role in learning outcomes.

The positive correlation between engagement and motivation highlights the importance of finalizing the utilized enrichment modules that stimulate active participation while also fostering students' intrinsic drive. This means activities should not only involve collaborative problem-solving but also emphasize personal relevance and autonomy, as these sustain motivation and translate into long-term achievement gains. The weak but significant correlation between motivation and academic performance suggests that while motivation alone does not guarantee higher grades, it creates the conditions for persistence, resilience, and deeper learning strategies. Therefore, enrichment modules should integrate goal-setting exercises, self-reflection prompts, and feedback mechanisms that help students transform motivation into tangible academic success.

The findings suggest that PBL is most effective when implemented through well-designed enrichment modules. To finalize further the enrichment modules for high school students, the researchers suggested the following:

- Embed **authentic, real-world problems** that make mathematics meaningful.
- Incorporate **collaborative and reflective tasks** to deepen engagement.
- Include **confidence-building and scaffolding activities** to strengthen self-efficacy.
- Integrate **test-anxiety management strategies**, supported by guidance services.
- Be adaptable to different grade levels, recognizing variations in student motivation.

Professional development for teachers is equally vital to ensure consistent and skillful facilitation of PBL. With these elements, enrichment modules can serve as a standardized, sustainable framework that empowers students to engage actively, stay motivated, and succeed academically and beyond.

Conflict of Interests

No potential conflict of interest.

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AI Declaration

AI tools were used only for grammar refinement and language clarity; all ideas, analyses, and conclusions are the researcher's own.

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