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Evaluation of the Effectiveness of the Intensive Mathematics Class Program through a Pretest-Posttest Study Using the Expository Method for Low Ability Students

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ABSTRACT

This study evaluates the effectiveness of the Intensive Mathematics Class Program (IMCP) - an expository teaching intervention designed to mitigate mathematics learning loss among low-achieving 10th-grade students at Sekolah Global Mandiri Cibubur, Indonesia, following by the fact of widespread COVID-19 educational disruptions (affecting 90% of learners globally) and documented declines in national PISA mathematics scores. Using a purposive sampling technique, 18 students with the lowest performance (three from each class) were selected to participate in structured instruction on quadratic equations, assessed through a pretest–posttest design. Results indicated significant improvement, with mean scores increasing from 1.33 (SD = 1.14) to 6.61 (SD = 3.47). Non-parametric tests (Shapiro–Wilk W = 0.806, p = 0.002) confirmed data non-normality and the effectiveness of the intervention, further supported by a large effect size, ES = 0.86. Notably, 17 out of 18 students demonstrated score improvements, while only 1 student showed no improvement. These findings show that systematic expository teaching can effectively bridge learning gaps. The study shows the effect of the IMCP as the strategy for low-achieving students in the post-pandemic context. However, the study's generalizability is limited by its small sample size and localized setting in Senior High School Global Mandiri Cibubur. In the future, the research recommends to expand participant diversity and sample size.

INTRODUCTION

The Indonesian education system faces significant challenges in mathematics learning, particularly concerning student demotivation and learning loss exacerbated by the pandemic (Lintang, 2025). Globally, school closures during the COVID-19 pandemic disrupted the education of over 90% of students worldwide, leading to extended academic disengagement and limited access to structured learning environments (Tarkar, 2020). This unprecedented disruption has intensified existing gaps in mathematics performance, especially among low-achieving students in Indonesia. This is evidenced by the decline in PISA mathematics scores from 379 in 2018 to 366 in 2022 (Kemendikbudristek, 2023), highlighting a critical need for targeted interventions. Research has consistently demonstrated the strong correlation between learning motivation and mathematics achievement (Lestari, 2017), suggesting that addressing motivational factors could improve outcomes. In response to these challenges, Global Mandiri High School Cibubur implemented the Intensive Mathematics Class Program (IMCP) using a pretest-posttest control group design (Creswell, 2014). This intervention specifically targeted the lowest-performing students in each class, employing an expository teaching approach to enhance conceptual understanding (Killen, 2023; Sanjaya, 2010; Siswondo & Agustina, 2021).

The IMCP employs a structured, teacher-centered expository method, characterized by direct instruction and systematic problem-solving demonstrations (Sanjaya, 2010). This approach aligns with research showing that intensive, small-group interventions can significantly improve academic performance, particularly in mathematics (Archer & Hughes, 2011; Fuchs et al., 2003). However, the effectiveness of such programs depends heavily on teachers' ability to adapt instruction to individual cognitive profiles (Connor et al., 2004). The current study evaluates the IMCP's efficacy by analyzing pretest-posttest results, focusing exclusively on its impact on low-achieving 11th-grade students (scoring below the minimum competency standard of 75). By isolating the expository method's effects, this study aims to contribute empirical evidence on its potential to mitigate learning gaps in mathematics.

The study by Sari et al. (2024) demonstrates that the implementation of pretest and posttest numeracy modules significantly enhances students' mathematical literacy, with particular emphasis on cognitive processes in numerical problem-solving. The findings reveal the most substantial improvement occurred in applied skills (74.07%), indicating that practical implementation factors dominate over basic knowledge or complex reasoning components. This aligns with the expository teaching methodology developed through IMCP in this study, which emphasizes applying mathematical concepts to real-world contexts. As evidenced by the pre-test/post-test results, this approach not only helps students understand theoretical concepts but also enables them to effectively implement these concepts in practical situations. The expository method's emphasis on scaffolding and systematic knowledge integration (Heal, 2023) directly supports these outcomes by addressing common mistakes such as cognitive overload and misconceptions.

While challenges such as resource limitations and accurate identification of learning barriers persist (Lyon et al., 2003; Kartini & Kristiawan, 2019), structured interventions like the IMCP offer a promising framework for improving educational equity. This study not only tests the method's effectiveness but also provides actionable insights for educators and policymakers seeking to enhance mathematics instruction in post-pandemic recovery efforts. The findings are expected to inform the design of remedial programs and bridge learning gaps, particularly for struggling learners who benefit most from the method's systematic approach. The combination of empirical evidence from Sari et al. (2024) and established pedagogical principles (Heal, 2023) creates a compelling case for adopting similar numeracy interventions in diverse educational settings.

This main objective of this research is to evaluate the impact of IMCP on students' understanding of fundamental concepts in solving quadratic equations. Using paired samples (pretest and posttest scores) from the lowest-performing mathematics students at Senior High School Global Mandiri Cibubur, this research first assess whether the data meet parametric or non parametric assumptions via normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) and homogeneity testing. In this research, the sample has the non-parametric distribution. The Wilcoxon Signed-Rank Test is used to compare the means of the non-parametric paired samples, with the null hypothesis stating that there is no difference between the pretest and posttest means. Finally, this research evaluate the effect size to quantify the intervention's magnitude.

METHODOLOGY

1. Research Design

This study used a quantitative approach with a one-group pretest-posttest design. This design was selected to measure the effectiveness of the Intensive Mathematics Class Program (IMCP) using the expository teaching method by comparing students' mathematical performance before (pretest) and after (posttest) the intervention in Figure 1.

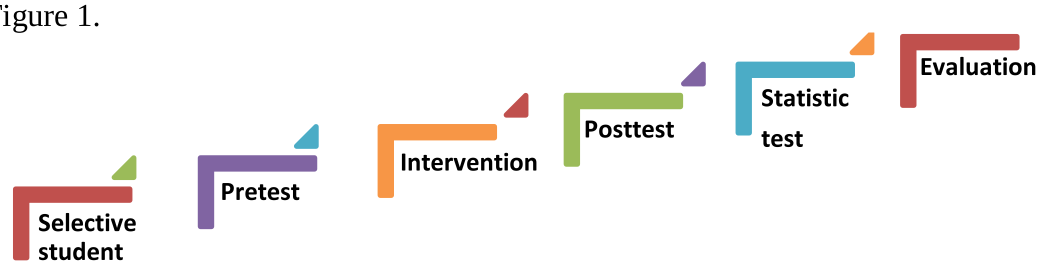

Fig 1. Methodological Steps for IMCP

The pretest, as indicated in the figure, served as a baseline assessment of students' mathematical competence before the program. Following the intervention, the same students were given a posttest, and their scores were compared to determine any significant improvement attributable to the program. In this paired design, both pretest and posttest represent the same dependent variable measured at two time points within the identical participant group, allowing for direct within-individual progress assessment (Kadir, 2015). This design allows researchers to evaluate the effectiveness of the instructional strategy while controlling for individual variability, since each student serves as their own control (Dugard and Todman, 2006).

2. Population and Sample

a. Population: the study targeted 152 students of 10th-grade at Global Mandiri High School Cibubur who scored below the Minimum average scores.
b. Sample: purposing sampling technique was applied (Syaban and Ratnaningrum, 2021), selecting 18 students (3 lowest-performing students from each of the 6 classes).

3. Data Collection Techniques

a. Pretest: a solving quadratic equations test to assess initial competency (for example, see Table 1).

b. Intervention: implementation of the expository teaching method, involving structured explanations, problem-solving demonstrations, and guided practice (for example, see Table 1).
c. Posttest: a parallel test (similar difficulty level but with different problems) to evaluate improvement after the intervention (for example, see Table 1).

Table 1

<table>
<tr><td>Pretest:
Solve the quadratic equation:

$x^2 + 5x + 6 = 0$</td><td colspan="2">Answer:</td></tr>
<tr><td>Criteria</td><td>Decription</td><td>Scores</td></tr>
<tr><td>Correctness of Answer</td><td></td><td></td></tr>
<tr><td>Problem-Solving Process</td><td></td><td></td></tr>
<tr><td></td><td>Total Scores</td><td></td></tr>
<tr><td colspan="3">Interventions:</td></tr>
<tr><td colspan="3">Solution:
• Step 1: $x^2 + 5x + 6 = 0 \rightarrow a = 1, b = 5,$ and $c = 6.$
• Step 2: $(x + p)(x + q) = 0 \rightarrow pq = 6$ and $p + q = 5.$
• Step 3: Since $c > 0 \rightarrow p$ and q have the same positive signs
$\rightarrow p = 2$ and $q = 3.$
• Step 4: $(x + 2)(x + 3) = 0 \rightarrow x = -2$ and $x = -3$
• Step 5: Solution $= \{-3.-2\}$</td></tr>
<tr><td>Posttest:
Solve the quadratic equation:

$2x^2 - x - 3 = 0$</td><td colspan="2">Answer:</td></tr>
<tr><td>Criteria</td><td>Decription</td><td>Scores</td></tr>
<tr><td>Correctness of Answer</td><td></td><td></td></tr>
<tr><td>Problem-Solving Process</td><td></td><td></td></tr>
<tr><td>Source : Data Processed in 2025</td><td>Total Scores</td><td></td></tr>
</table>

4. Assessment rubric

This study used a 6-point interval-scale assessment rubric to comprehensively evaluate student performance across two key mathematical competencies: Correctness of Answer and Problem-Solving Process. The rubric's scoring system (0-6) operates as interval-level measurements, where numerically equal intervals correspond to qualitatively equivalent performance increments, as detailed in Table 2. Following Zumbo's (2023) conceptualization, this interval scale maintains ordinal properties while allowing meaningful comparison of score differences, though the zero point remains arbitrary rather than representing a true absence of mathematical ability. This measurement approach enables parametric statistical analysis of learning gains while accounting for the non-absolute zero characteristic of educational performance scales.

Table 2

Criteria	Score	Description
Correctness of Answer	0-6	• 6 points: fully correct solution with complete steps. • 5 points: correct answer with minor missing steps. • 4 points: partially correct answer with complete steps. • 3 points: partially correct answer with incomplete working. • 2 points: incomplete answer but correct steps. • 1 point: incorrect solution. • 0 point: no response.
Problem-Solving Process	0-6	• 6 points: systematic and complete process. • 5 points: correct process with minor error process. • 4 points: partially correct process with complete process. • 3 points: partially correct process with incomplete process. • 2 points: begun correctly process but unfinished. • 1 point: incorrect approach. • 0 point: no attempt.

Source : Data Processed in 2025

5. **Intervention Method**

Following after the pretest, the student received structured explanation and problem solving demonstrations using the factoring method. The standard form is $x^2 + bx + c = 0$ that was solved through the following systematic steps.

a. Equation preparation: checking the coefficient of x^2 is 1.
b. Factored form: guiding to establish the factor form: $(x + p)(x + q) = 0$, where $p \times q = c$ (constant term) and $p + q = b$ (coefficient of x)
c. Factor identification process: identify all factor pairs of constant term c, select the pair whose sum equals coefficient b, and determine the sign of c: $c > 0 \rightarrow$ both factors have sign as b, and $c < 0 \rightarrow$ both factors have opposite signs (larger factor matches with b sign.
d. Solution Derivation: the zero-product was applied.
e. Presented Answer: solutions are in the set of solutions (ascending order).

6. **Data Analysis Techniques**

Analyses (a), (b), (d), and (e) were conducted using IBM SPSS Statistics 18 with the following procedures.

a. Statisics Descriptive: to compare statistic mean and standard deviaton beetween two groups (Pallant, 2020).

b. Normality Test: The Kolmogorov -Smirnov and The Shapiro-Wilk test were used to assess whether the sample data followed a normal distribution.
c. Homogeneity Test: The t-student was conducted to verify the equality of variances between two dependent groups, it can be written as Formula 1 below (Kadir, 2015):

$$t = \frac{|{s_1}^2 - {s_2}^2|}{2s_1s_2\sqrt{\frac{1-{r_{12}}^2}{n-2}}}$$

Formula 1: t-statistic for homogeneity test.

Where, ${s_1}^2$ is a variance of pretest, ${s_2}^2$ is a variance of posttest, and r_{12} is a coefficient correlation between pretest and posttest. Statistical significance was set at p < 0.05. The hypotheses for this test were hypothesis:
1) $H_0: {\sigma_1}^2 = \sigma_2^2$
2) $H_1: {\sigma_1}^2 \neq \sigma_2^2$.

d. Wilcoxon Signed-Rank Test was used as a non-parametric alternative if data were non-normal. The hypothesis:
1) $H_0: \mu_{diff} = 0$,
2) $H_1: \mu_{diff} \neq 0$.

Statistical significance was set at $p < 0.05$, and here is the algorithm steps for paired samples, $n \leq 30$ (Herrhyanto and Gantini, 2020):
1) Calculated differences for each paired observation.
2) Rank the absolute differences.
3) Sum positive signed rank (ΣR_+) and sum negative signed rank (ΣR_-)
4) Z-statistik: find the minimum between (ΣR_+) and (ΣR_-).
5) Criteria of hypothesis test: if $Z \leq Z_{\alpha;n}$, then H_0 is rejected.

e. Effect Size: to determine the magnitude of the intervention effect, it can be calculated by using the formula (Corder and Foreman, 2014).

$$\mathrm{ES} = \frac{|z|}{\sqrt{n}}$$

Formula 2: The formula of Effect Size

Classification of Effect Size (ES):
1) $0 \leq \mathrm{ES} \leq 0.29$ → weak effect.
2) $0.30 \leq \mathrm{ES} \leq 0.49$ → moderate effect.
3) $0.50 \leq \mathrm{ES} \leq 1$ → strong effect.

RESULTS AND DISCUSSION

This research examined 18 low achieving mathematics students out of a total of 152 grade 10th students from six classes at Global Mandiri High School Cibubur using a pretest and posttest design. The initial pretest revealed that all participants could not solve quadratic equations (a foundation topic in mathematics taught at the junior high school level), with pretest scores ranging from 0 to 4 (mean = 1.333, standard deviation = 1.138). These findings demonstrate that while quadratic equations should have been mastered in middle school, these mathematically weak high school students showed no understanding of either the concepts or solutions of quadratic equations, indicating significant learning loss and an inability to adapt to high school mathematics requirements. Following the targeted interventions, the posttest results showed improvement (mean = 6.611, standard deviation = 3.466). In the descriptive analysis (Table 3), the increase in mean between two test scores suggests that the expository teaching method was effective for the sample. The results presented in Tables 2 through 6 are derived from primary data collected during school hours in physical education and arts classes, with all assessments recorded and stored in Excel format (Yehezky, 2025).

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Table 3

	N	Minimum	Maximum	Mean	Std. Deviation
PRETEST	18	0.00	4.00	1.333	1.138
POSTTEST	18	1.00	12.00	6.611	3.466

Source : Data Processed in 2025

Khatun (2021) found that the Shapiro-Wilk test is one of the most powerful normality tests for sample sizes ranging from 10 to 300. In this study, the Shapiro-Wilk test was used to assess the normality assumption, with pretest scores serving as the primary indicator. The analysis focused on a sample of n = 18, which included only the three lowest-performing students from each class rather than the entire school population. As shown in Table 4, both the Kolmogorov-Smirnov (D = .277, p = 0.001) and Shapiro-Wilk (W = .806, p = 0.002) tests shows statistically significant results ($p < .05$), leading to the rejection of the null hypothesis of normal distribution.

Table 4

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic (D)	df	Sig.	Statistic (W)	df	Sig.
PRETEST	.277	18	0.001	.806	18	0.002

Source : Data Processed in 2025

The analysis of the homogeneity test revealed significant heterogeneity of variances between pretest and posttest scores, with pretest variance $s_1^2 = 1.294$ being markedly lower than posttest variance $s_2^2 = 12.0163$. The weak correlation between paired observations, $r_{12} = 0.1392$, and t-statistics test; $t = 5.4921 < t_{(0,05)(16)} = 2.120$. It implies that the hypothesis H_0 is rejected. It means the variance of the two samples data is heterogen. Since the sample data did not meet the assumptions of normality and homogeneity significantly, the non-parametric Wilcoxon signed-rank test was employed to determine whether the difference between Pretest and Posttest scores was statistically significant.

Table 5

Rank		N	Mean Rank	Sum of Ranks
POSTTEST-PRETEST	Negative Ranks R_-	0	0.00	0.00
	Positive Ranks R_+	17	9.00	153.00
	Ties	1		
	Total	18		

Source : Data Processed in 2025

The non-parametric Wilcoxon Signed-Rank test analysis presented in Table 5 demonstrates that the learning intervention significantly improved student outcomes. The ΣR_+ value of 17 indicates that the most students (17 out of 18) showed higher post-test scores compared to pre-test scores. Meanwhile, the score ΣR_- is 0 confirms that none of the students experienced any performance decline after the intervention. One tied rank case was identified, meaning one student maintained the same score.

Based on the results of the Wilcoxon Signed Rank Test calculation in Table 6, the obtained Z value was -3.626 indicates the direction of change (Based on negative ranks) with the extremely small p-value (Asymp. Sig. 2-tailed) of 0.000, which is below the critical research threshold of 0.05. Therefore, the hypothesis decision is to reject H_0, meaning there is a statistically significant difference between the pretest and posttest groups.

Table 6

	POSTTEST-PRETEST
Z	-3.626
$Asymp. Sig. (2 - tailed)$	0.000

Source : Data Processed in 2025

The large effect size (ES = 0.86, calculated by using formula 2) significantly exceeds the threshold for large effects (ES ≥ 0.50), indicating that the expository teaching method in IMCP had a substantial and statistically meaningful impact on student outcomes.

CONCLUSION

This study has evaluated the effectiveness of the Intensive Mathematics Class Program (IMCP) using the expository teaching method to improve learning outcomes among low-achieving 10th-grade students at Global Mandiri High School Cibubur.

The pretest-posttest analysis revealed significant improvements, with mean scores increasing from 1.33 (SD = 1.14) to 6.61 (SD = 3.47). Non-parametric analysis (Shapiro-Wilk W = 0.806, p = 0.002) conducted on the sample of 18 students confirmed a non-normal data distribution, while follow-up testing demonstrated statistically significant post-intervention gains. The large effect size (ES = 0.86) further emphasized the intervention's practical impact, with 17 out of 18 students showing measurable improvement. These findings support the expository method is effective to improve the score. However, the small sample size (N = 18) and 1 non-responsive case suggest opportunities for further research on individualized adaptations. For educators and policymakers, these results suggest that structured, teacher-led instruction can be a viable strategy for supporting low-achieving students, particularly in contexts where foundational gaps exist. Schools may consider integrating similar targeted interventions into remedial curricula, paired with teacher training on expository techniques. However, the small sample size (N = 18) and 1 non-responsive case limit generalizability and highlight the need for future research with larger, more diverse populations. Further studies could explore how student-specific factors (e.g., prior knowledge, motivation) moderate the method's efficacy, as well as long-term retention of gains.

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