



Integrating Mindful Learning and Joyful Learning into Junior High School Students' Mathematical Critical Thinking and Communication

***Harist Permana Sandy, Tri Dyah Prastiti, Idha Novianti**

Master's Program in Mathematics Education, Universitas Terbuka, Banten, Indonesia

*Corresponding author e-mail: haristpermanasandy69@gmail.com

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Abstract

Indonesian junior high school students' mathematical critical thinking and mathematical communication remain low, as indicated by PISA 2022 and several local studies on statistics material. This study examined the effect of integrating Mindful Learning and Joyful Learning, operationalized through a five-phase instructional syntax (Mindful Opening, Joyful Exploration, Mindful Processing, Joyful Communication, Mindful Closing), on both abilities among eighth-grade students. A quasi-experimental Nonequivalent Control Group Pretest-Posttest design was used, involving 64 students from SMP Negeri 1 Jabon, Sidoarjo, assigned to an experimental group ($n = 32$), taught by the researcher, and a control group ($n = 32$), taught by the school's mathematics teacher. Baseline equivalence was confirmed for both abilities ($p > .05$). The pretest instrument was piloted on 60 students and found valid and reliable (Cronbach's Alpha = 0.977); the posttest, an equivalent form, was expert-validated (Instrument Validity Index = 0.88). The experimental group showed significantly greater N-Gain than the control group for mathematical critical thinking (Mann-Whitney U, $p < .001$, $r = .476$) and mathematical communication ($t(62) = 2.539$, $p = .014$, Cohen's $d = .635$), with mean N-Gain of 0.356 and 0.339 (moderate category), compared with 0.133 and 0.198 in the control group (low category). A significant but weak positive correlation was found between the N-Gains of both abilities in the experimental group (Spearman's $\rho = .373$, $p = .036$), interpreted cautiously. Given the nonrandomized design, these results indicate a statistically significant improvement of moderate magnitude, with medium-to-large effect sizes; causal attribution is limited by the quasi-experimental design, including non-random assignment of intact classes and different teachers for the two groups.

Keywords: Joyful learning; Mathematical communication; Mathematical critical thinking; Mindful learning; Statistics

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INTRODUCTION

Mathematical critical thinking and mathematical communication are two fundamental competencies that constitute the main demands of 21st-century mathematics learning, since they determine the extent to which students are able to analyze information logically and communicate ideas effectively (Kurniawati & Ekayanti, 2020; Yulian et al., 2023). Mathematical critical thinking encompasses the processes of interpreting, analyzing, evaluating, and drawing inferences about mathematical arguments (Facione, 2015), while mathematical communication refers to the ability to express and construct mathematical understanding, both orally and in writing, through symbols, graphs, and tables (Maulyda, 2020; National Council of Teachers of Mathematics, 2000).

Achievement in both abilities remains far from expectations. The PISA 2022 results show that the average mathematics score of OECD countries declined by 15 points from 2018, with Indonesia's performance in reasoning about and communicating mathematical ideas falling into

the low category (OECD, 2023). At the local level, junior high school students' mathematical critical thinking ability on statistics material was found to be in the low category, with a mean score of 46.87 on a scale of 100 (Suryani & Haryadi, 2022; Wijayanti et al., 2024); similarly, mathematical communication ability remains below the minimum mastery criterion (Sa'adah & Sumartini, 2021). Similar findings have also been reported across various grade levels and other topics (Fitriani et al., 2022; Ikhsan & Afriansyah, 2023; Ismayanti & Sofyan, 2021; Prastianti et al., 2022; Shabrina et al., 2023; Suhenda & Munandar, 2023). The relationship between junior high school students' mathematical critical thinking and self-efficacy has also been widely studied (Haqqul & Saraswati, 2023; Prajono et al., 2022; Riyanto & Mariani, 2019; Sukma & Priatna, 2021).

This condition stems from two interrelated root causes, namely weak reflective cognitive stimulation and a mathematics learning atmosphere that tends to be tense, which triggers learning anxiety or math anxiety (Zuo & Wang, 2023). Similar mathematics anxiety conditions have also been widely reported among junior high school students in Indonesia (Julya & Nur, 2022; Nuraeni & Munandar, 2023; Nurhidayat & Djidu, 2022). The solution required is twofold: strengthening students' awareness and reflective thinking while simultaneously building their emotional engagement and communicative courage (Mas'ula et al., 2025). Mindful Learning, an approach that emphasizes full awareness, focused attention, and reflection on the thinking process (Langer, 1997, 2008), has been shown to be effective in strengthening critical-thinking capacity through the cognitive-metacognitive pathway (Davenport & Pagnini, 2016; Shintawati et al., 2023; Saleh et al., 2025; Yi et al., 2024). Joyful Learning, an approach that emphasizes an enjoyable, psychologically safe learning atmosphere that fosters social interaction (Rogers, 1969), has been shown to be effective in strengthening mathematical communication through the affective-social pathway (Jeet & Pant, 2023; Anjariyah & Putri, 2025; Putra et al., 2026).

The theoretical basis for pairing these two pathways is grounded in the developmental characteristics of early adolescents. At this stage, students are entering the capacity for abstract and hypothetical reasoning (Piaget, 1973) while remaining highly sensitive to social acceptance and emotional safety in group settings (Erikson, 1968). Mathematical critical thinking, which requires sustained attentional control and reflective self-regulation, is therefore expected to respond primarily to the cognitive-metacognitive mechanisms that Mindful Learning provides: focused attention reduces cognitive load and creates the reflective space needed for analysis, evaluation, and inference (Facione, 2015; Langer, 1997). Mathematical communication, in contrast, depends on the learner's willingness to externalize reasoning in front of peers, a willingness that is primarily gated by perceived psychological safety and intrinsic motivation (the affective-social mechanisms that Joyful Learning is designed to supply; Rogers, 1969; Csikszentmihalyi, 1990). Because these two competencies are hypothesized to be gated by different psychological mechanisms, an instructional design that addresses only one pathway (as in most prior single-approach studies) would be expected to leave the other competency comparatively under-supported. This dual-mechanism rationale is the theoretical basis for combining, rather than choosing between, Mindful Learning and Joyful Learning within a single instructional sequence, and it generates the expectation (explored in this study) that the two gains would be positively but only moderately correlated, since each is driven by a partially distinct mechanism operating within the same instructional episode.

Prior research on Mindful Learning and Joyful Learning has focused predominantly on general learning outcomes, mathematics anxiety, or learning motivation, without specifically examining their effect on mathematical critical thinking and mathematical communication as two variables measured simultaneously within a single integrated instructional framework (Mas'ula et al., 2025). A combined mindful, meaningful, and joyful learning model has indeed begun to be examined at the elementary school level (Siregar et al., 2026); however, research

at the junior high school level that measures mathematical critical thinking and mathematical communication simultaneously remains limited.

The novelty of this study is threefold and is stated explicitly here. First, at the conceptual level, the study proposes and explores, in a preliminary way, a dual-mechanism theoretical model in which Mindful Learning and Joyful Learning are hypothesized to act on two different competencies through two distinct psychological pathways within the same lesson sequence, rather than being combined merely as an additive set of techniques. Second, at the instructional-design level, the study contributes a five-phase syntax (Mindful Opening, Joyful Exploration, Mindful Processing, Joyful Communication, Mindful Closing) that operationalizes this model into a sequence in which each phase is mapped to a specific target indicator of critical thinking or communication (detailed in the Method section). Third, at the empirical level, the study is, to the authors' knowledge, among the first to measure mathematical critical thinking and mathematical communication simultaneously at the junior high school level using authentic school-based (Adiwiyata) statistics data as the instructional context, and to test the relationship between the gains in the two abilities directly.

Statistics was selected as the research context because its characteristics require students to actively read, process, and communicate data, aligning it with the principles of Mindful Learning while also opening discussion space that supports Joyful Learning, consistent with the emphasis placed on critical thinking specifically within the context of statistics (Agustina et al., 2023). Based on the foregoing, this study aims to examine the effect of integrating Mindful Learning and Joyful Learning on junior high school students' mathematical critical thinking and mathematical communication in statistics material.

METHOD

This study is a quantitative study using a quasi-experimental approach with a Nonequivalent Control Group Pretest-Posttest design (Creswell & Creswell, 2023), which is commonly used to test the effectiveness of an instructional model by comparing two intact classes (Assuah et al., 2022). Consistent with the nonrandomized nature of this design, causal claims in this study are framed as supported rather than definitively established, and are qualified throughout by the statistical baseline-equivalence evidence and fidelity data reported below. The research design is presented in Table 1.

Table 1. Nonequivalent Control Group Pretest-Posttest Quasi-Experimental Design

Group	Pretest	Treatment	Posttest
Experimental	O ₁	X	O ₂
Control	O ₁	—	O ₂

Note: O₁ = pretest; O₂ = posttest of mathematical critical thinking and mathematical communication ability; X = treatment in the form of instruction integrating Mindful Learning and Joyful Learning.

The research subjects were 64 eighth-grade students of SMP Negeri 1 Jabon, Sidoarjo Regency, in the 2025/2026 academic year, assigned through purposive sampling into class 8J as the experimental group (32 students) and class 8F as the control group (32 students). The experimental class was taught by the researcher (five years of teaching experience), and the control class was taught by the school's mathematics teacher (years of experience not formally recorded) using conventional expository (lecture-based) instruction, for an equal number of meetings. Because each group was taught by a different teacher, teacher effects cannot be fully separated from the treatment effect, which is acknowledged as a limitation of this study.

Both groups covered the same statistics content across eight meetings: the first and eighth meetings were used for the pretest and posttest, while the five-phase syntax (experimental group) or conventional expository instruction (control group) was implemented across meetings two through seven, with meetings 1, 3, 5, and 8 lasting 3×40 minutes and meetings 2, 4, 6, and 7 lasting 2×40 minutes, according to the school's timetable allocation.

Baseline Equivalence Between Groups

Prior to treatment, an independent samples t-test was conducted on the pretest scores of both dependent variables to provide statistical evidence (rather than relying solely on the assumption of equivalent initial academic ability) that the two groups did not differ significantly at baseline. Shapiro-Wilk tests indicated that pretest scores for both variables were normally distributed in both groups ($p > .05$), and Levene's test confirmed homogeneity of variance ($p > .05$), satisfying the assumptions for the t-test. The results showed no significant difference between the experimental group ($M = 34.56$, $SD = 10.42$) and the control group ($M = 32.57$, $SD = 8.61$) on the pretest for mathematical critical thinking, $t(62) = 0.83$, $p = .410$, nor between the experimental group ($M = 33.99$, $SD = 12.44$) and the control group ($M = 31.06$, $SD = 10.47$) on the pretest for mathematical communication, $t(62) = 1.02$, $p = .312$. These results confirm that the two groups began the study with statistically equivalent initial ability on both dependent variables.

Instruments and Their Validation

The research instruments consisted of an essay test of mathematical critical thinking ability developed based on Facione's (2015) indicators, and an essay test of mathematical communication ability referring to NCTM (2000) and Qohar (2011). The pretest instrument, consisting of 21 items, was empirically piloted on 60 Grade IX students from the same school, outside the research sample. Item validity testing using the Pearson Product Moment correlation showed that all 21 items were valid ($r = 0.537$ - 0.901 ; r -table = 0.254 for $n = 60$ at a 5% significance level), and reliability testing using Cronbach's Alpha yielded a coefficient of 0.977 (very high; Guilford, 1956; Zakariya, 2022). Computed separately for each instrument, Cronbach's Alpha was 0.959 for the 13 critical-thinking items and 0.948 for the 8 communication items. Item-difficulty analysis showed 1 easy, 14 moderate, and 6 difficult items (difficulty indices rounded to two decimals); discrimination-index analysis showed 17 items in the good category and 4 in the fair category, with none classified as poor. All 21 items were therefore retained. Validity and reliability were tested on the pretest form using the Product Moment correlation and Cronbach's Alpha (Azwar, 2015), consistent with common practice in mathematics-education instrument-development research (Amelia & Erita, 2024; Qohar & Fauziyah, 2024). This approach to testing the validity and reliability of mathematical-ability test instruments has also been applied in similar studies (Wahyuni, 2022).

The posttest instrument was developed as an equivalent form, matched to the pretest in indicator structure, and was validated through expert judgment rather than empirical piloting. The two forms use identical sub-item wording and the same maximum scores (52 for critical thinking and 32 for communication), differing only in context and numerical values. Validity was quantified using the Validity Item Score (Skor Validitas Item, SVI) and Instrument Validity Index (Indeks Validitas Perangkat, IVP) procedure of Widaningsih et al. (2025). Three expert raters (a mathematics education lecturer and two mathematics subject teachers) independently rated each item on a 1-4 scale against the test blueprint (kisi-kisi); the SVI for each item was computed as the sum of ratings divided by (number of raters $\times$ maximum score), and the IVP was the mean SVI across items. The posttest instrument obtained $IVP = 0.88$ (very good category, ≥ 0.80), and the pretest instrument (additionally rated through the same expert procedure prior to piloting) obtained $IVP = 0.87$. Because both forms were built from the same blueprint and rated by the same three experts using the same criteria, the two forms are considered comparable in content and structure for computing N-Gain, although empirical evidence of equivalence is lacking; we nonetheless flag the absence of an empirical (student-response) pilot for the posttest as a limitation (see Research Limitations).

Five-Phase Instructional Syntax and Its Theoretical Linkage to Target Indicators

The five-phase syntax used in the experimental group was developed by the researchers based on the core mechanisms of Mindful Learning (attention, reflection, self-regulation;

Langer, 1997, 2008) and Joyful Learning (psychological safety, intrinsic motivation, social interaction; Rogers, 1969; Csikszentmihalyi, 1990), sequenced so that mental readiness is established before exploration, and reflective processing precedes communicative expression. The lesson plan, including the student worksheets, was validated by three experts (IVP = 0.89, very good category). Table 2 summarizes, for each phase, its primary psychological mechanism and the specific critical-thinking or communication indicator it is intended to develop.

Table 2. Theoretical Linkage Between the Five-Phase Syntax and Target Indicators

Phase	Primary Mechanism	Targeted Indicator
1. Mindful Opening	Attentional readiness (Langer, 1997)	Precondition for both abilities: focused attention before content engagement
2. Joyful Exploration	Intrinsic motivation, contextual engagement (Rogers, 1969)	Precondition for communication: curiosity and willingness to engage with real (Adiwiyata) data
3. Mindful Processing	Reflective self-regulation (Langer, 1997; Vygotsky, 1978)	Critical thinking: analysis, evaluation, and inference (Facione, 2015)
4. Joyful Communication	Psychological safety, social interaction (Rogers, 1969)	Communication: discussion, argumentation, representation (NCTM, 2000)
5. Mindful Closing	Meaningful closure (Ausubel, 1978)	Consolidation of both abilities through structured reflection

Instructional Implementation Fidelity Observation

To ensure that the treatment was implemented as designed (fidelity of implementation), an observer (a mathematics teacher who did not deliver the instruction) rated the experimental group's instruction at every meeting using a two-part observation sheet: (1) implementation of the five-phase syntax, and (2) the teacher's facilitation of mathematical critical thinking and mathematical communication. Each aspect was rated on a 1-4 scale (maximum total score = 128 per meeting; categories: 32-57 poor, 58-83 fair, 84-109 good, 110-128 very good). Because only one observer rated all sessions, no inter-observer reliability coefficient is available; the 89.45% mean fidelity score reported below should therefore be interpreted as a single-rater estimate rather than a fully corroborated measure.

Data were analyzed using the Normalized Gain (N-Gain) score following Hake's (1998) criteria. A Shapiro-Wilk normality test was conducted as a prerequisite test prior to hypothesis testing on the N-Gain scores; where the N-Gain of either group departed from normality, the Mann-Whitney U test was used as a non-parametric alternative to the Independent Samples t-Test. Effect sizes are reported alongside all inferential tests: the effect size $r = Z/\sqrt{N}$ for the Mann-Whitney U test, and Cohen's d together with the 95% confidence interval for the mean difference for the independent t-test, following Cohen's (1988) conventions. Spearman's rank correlation was used to examine the relationship between the N-Gain of mathematical critical thinking and mathematical communication in the experimental group, because the N-Gain of critical thinking in this group was not normally distributed (Shapiro-Wilk $p = .023$).

The study was conducted at SMP Negeri 1 Jabon from 8 to 18 June 2026 with the permission of the school principal, who served as the institutional authority responsible for the students during the research; the school subsequently certified the research in a completion letter (No. 400.3.10/915/438.5.1.1.44/2026, dated 26 October 2026), and this permission is acknowledged in the Acknowledgments section.

RESULTS AND DISCUSSION

Results

Before reporting the results of hypothesis testing, the implementation of instruction in the experimental group is reported first. The mean implementation score across the six meetings reached 89.45% (very good category), with a consistent upward trend from the second

meeting (82.8%) to the seventh meeting (95.3%). As noted above, this figure reflects a single observer's ratings and should be read as indicative rather than definitive evidence of fidelity.

As reported in the Method section, baseline equivalence testing confirmed no significant pretest difference between groups for either mathematical critical thinking ($t(62) = 0.83$, $p = .410$) or mathematical communication ($t(62) = 1.02$, $p = .312$). Descriptive statistics for the pretest and posttest scores of both groups are presented in Table 3.

Table 3. Descriptive Statistics of Pretest-Posttest Scores for Mathematical Critical Thinking (Y1) and Mathematical Communication (Y2)

Variable	Group	Pretest (M ± SD)	Posttest (M ± SD)
Critical Thinking (Y1)	Control	32.57 ± 8.61	42.25 ± 10.31
	Experimental	34.56 ± 10.42	59.19 ± 12.02
Communication (Y2)	Control	31.06 ± 10.47	46.19 ± 11.50
	Experimental	33.99 ± 12.44	57.81 ± 12.37

After the treatment, the experimental group showed a larger shift in category and mean score than the control group, with effect sizes now reported alongside each test (Table 4).

Table 4. Mean N-Gain, Hypothesis-Testing Results, and Effect Sizes for Mathematical Critical Thinking (Y1) and Mathematical Communication (Y2)

Variable	Group	Mean N-Gain	Category	Test Statistic	Sig.	Effect Size
Critical Thinking (Y1)	Exp.	0.356	Moderate	Mann-Whitney U, Z = 3.807	< .001	$r = .476$
	Cont.	0.133	Low			
Communication (Y2)	Exp.	0.339	Moderate	Ind. t-Test, $t(62) = 2.539$	.014	$d = .635$; 95% CI of the mean difference [.030, .253]
	Cont.	0.198	Low			

In the experimental group, the distribution of N-Gain categories for mathematical critical thinking showed that 71.9% of students fell into the moderate category and 28.1% into the low category, with none reaching the high category. For mathematical communication ability, 50.0% of students fell into the moderate category, 46.9% into the low category, and 3.1% into the high category. As a complementary finding, Spearman's rank correlation showed a significant but weak positive relationship between the gains in the two abilities in the experimental group ($\rho = .373$, $p = .036$); given its modest magnitude, this result is not central to the study's main conclusions.

Discussion

The results of the Mann-Whitney U test ($Z = 3.807$, $p < .001$, $r = .476$) indicate a statistically significant and, by conventional benchmarks, medium-to-large-sized greater increase in mathematical critical thinking ability in the group receiving the integrated Mindful-Joyful instruction compared with conventional instruction. Baseline equivalence was confirmed statistically and implementation fidelity was rated by one observer; however, because intact classes were not randomly assigned and the two groups were taught by different teachers, the observed difference cannot be attributed to the treatment with certainty. This finding is consistent with Langer's theory (1997, 2008) that full awareness, openness to new perspectives, and reflection on the thinking process strengthen students' analytical and evaluative abilities. The Mindful Processing and Mindful Closing phases applied at every meeting trained the indicators of interpretation, analysis, evaluation, and inference proposed by Facione (2015), consistent with the phase-to-indicator linkage summarized in Table 2. This finding aligns with Saleh et al. (2025) and Shintawati et al. (2023) on the role of mindfulness-based and metacognitive instruction in thinking flexibility and critical thinking, and with Yi et al. (2024) on mindfulness-based conditional mathematics tasks. In line with this, students'

mathematical critical thinking ability has also been shown to improve through open-ended questioning strategies and reflective metacognitive approaches (Febintatias et al., 2025; Monrat et al., 2022; Padilah et al., 2025; Sachdeva & Eggen, 2021).

The results of the Independent Samples t-Test ($t(62) = 2.539$, $p = .014$, Cohen's $d = .635$; 95% CI of the mean difference [.030, .253]) show that the increase in mathematical communication ability was also significantly greater in the experimental group, with a medium effect size. This finding corresponds to the socially interactive character of Joyful Learning, which fosters interaction, collaboration, and the courage to express ideas (Rogers, 1969; Sutrina et al., 2025). The Joyful Exploration and Joyful Communication phases provided space for discussion and group presentations that trained students to express and interpret mathematical ideas in accordance with the principles of NCTM (2000) and Qohar (2011), consistent with recent empirical findings at the junior high school level (Ikhsan & Afriansyah, 2023; Suhenda & Munandar, 2023) and with Hladký et al. (2025) on mindfulness-based environments reducing math anxiety without sacrificing outcomes.

Although statistically significant, the practical magnitude of improvement in both abilities reached only the moderate N-Gain category, and no student attained the high category for mathematical critical thinking. Observer notes accompanying the fidelity ratings indicated that facilitation of mathematical communication lagged relatively behind facilitation of critical thinking during the early meetings, narrowing only by the sixth and seventh sessions as students became more accustomed to the Joyful Communication activities; this process-level observation offers only a tentative, descriptive indication of why gains may have plateaued at a moderate rather than high level within six meetings, alongside two data-based observations: Joyful Communication had the lowest fidelity score (80.0%), and all five items of the final problem set were classified as difficult in the pilot. This is consistent with the view that metacognitive awareness requires continued habituation that cannot be achieved instantly within a short intervention (Alvarez-Tinajero et al., 2026). The use of real data from the school's Adiwiyata program as an authentic learning context may have supported student engagement, although engagement was not measured directly, consistent with Mashuri and Yudasari (2024).

As a complementary finding, the positive but weak correlation between the gains in mathematical critical thinking and mathematical communication ($\rho = .373$, $p = .036$) is statistically significant yet modest in magnitude, explaining only about 14% of shared variance. This pattern is broadly compatible with the dual-mechanism model outlined in the Introduction, in which the two abilities are expected to develop through partially distinct psychological pathways (Facione, 2015; Sachdeva & Eggen, 2021; Jeet & Pant, 2023; Feriyanto et al., 2024). However, given the weak effect size, this correlation should be treated as a secondary, suggestive observation rather than confirmatory evidence of distinct developmental mechanisms, and it does not alter the primary conclusions drawn from the main hypothesis tests above. Replication with mediation or structural models in future research would be needed to test this explanation more directly.

Research Limitations

This study has several limitations that should be considered when interpreting the findings. First, the study involved only one school with a purposive, non-randomized sampling procedure; although baseline equivalence was confirmed statistically, generalization to a broader population should be undertaken with caution and causal claims remain bounded by the absence of individual random assignment. Second, empirical piloting of the instrument was conducted only on the pretest, while the posttest was validated through expert judgment (IVP = 0.88) as an equivalent form; the absence of an empirical, student-response pilot for the posttest remains a methodological limitation for the precision of the N-Gain estimates. Third, although implementation fidelity was observed at every meeting with a high mean score (89.45%), observation was conducted by a single rater without inter-observer reliability, so this

figure should be read as a single-rater estimate. Fourth, the weak correlation between the gains in the two abilities ($\rho = .373$) should be interpreted as suggestive of, rather than conclusive evidence for, distinct developmental pathways. Fifth, the experimental and control classes were taught by different teachers (the researcher and the school's mathematics teacher), so teacher effects cannot be separated from the treatment effect. Sixth, the pilot was conducted with Grade IX rather than Grade VIII students, and the discrimination index was computed with upper and lower 27% groups, so a different grouping could yield different values. Seventh, student responses to the Mindful and Joyful phases and to the Adiwiyata data were not measured with instruments. Eighth, formal permission for this study was obtained through the school principal as the institutional authority responsible for the students; separate parental consent and student assent were not sought, and the school gave permission on behalf of the students. Ninth, pretest-posttest correlations were low within both groups (critical thinking / communication: control $r = .20 / -.13$; experimental $r = -.09 / .06$), suggesting limited stability of individual rankings across the two parallel forms, so individual-level N-Gain values should be interpreted cautiously.

CONCLUSION

The integration of Mindful Learning and Joyful Learning was associated with a statistically significant and moderately-to-largely sized greater improvement in eighth-grade junior high school students' mathematical critical thinking (Mann-Whitney U, $Z = 3.807$, $p < .001$, $r = .476$) and mathematical communication (independent t-test, $t(62) = 2.539$, $p = .014$, Cohen's $d = .635$) on statistics material, compared with conventional instruction, following confirmed baseline equivalence between groups. The mean N-Gain of the experimental group for both abilities fell into the moderate category (0.356 and 0.339), higher than that of the control group (0.133 and 0.198); this indicates a statistically significant improvement of moderate magnitude that does not yet reach mastery level. Effect sizes ($r = .476$; $d = .635$) help convey the practical importance of these gains; however, because the outcomes were measured with researcher-developed tests in a nonrandomized design, practical significance should be interpreted cautiously. A significant but weak positive relationship ($\rho = .373$, $p = .036$) was also found between the gains in the two abilities in the experimental group, a pattern consistent with (but not conclusive proof of) the hypothesis that the two competencies develop along partially distinct pathways: a reflective cognitive-metacognitive pathway supported by Mindful Learning and an affective-social pathway supported by Joyful Learning. Because the study used a nonrandomized quasi-experimental design in a single school, these conclusions should be understood as statistically significant within this sample while remaining provisional with respect to generalizability and strict causal attribution.

RECOMMENDATION

Mathematics teachers are advised to implement the five-phase syntax consistently, extending the duration of the Mindful Closing phase to strengthen the internalization of metacognitive awareness, and to increase opportunities for presentation and discussion in the Joyful Communication phase, given the still-high proportion of students in the low category for mathematical communication. Future researchers are advised to: extend the duration of the treatment; expand the sample to more than one school using randomized or matched designs where feasible; involve more than one observer to calculate inter-observer reliability; empirically pilot the posttest instrument with student responses in addition to expert judgment; report effect sizes and confidence intervals as standard practice; and examine, through mediation or structural equation modeling, whether the hypothesized cognitive-metacognitive and affective-social pathways can be more directly tested as mechanisms linking the two abilities.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Harist Permana Sandy	√	√			√	√		√	√					
Tri Dyah Prastiti				√						√		√		
Idha Novianti				√						√		√		

C: Conceptualization; M: Methodology; So: Software; Va: Validation; Fo: Formal analysis; I: Investigation; R: Resources; D: Data curation; O: Writing – original draft; E: Writing – review & editing; Vi: Visualization; Su: Supervision; P: Project administration; Fu: Funding acquisition.

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

This study was conducted at SMP Negeri 1 Jabon from 8 to 18 June 2026 with the permission of the school principal, as certified by the school's research completion letter (No. 400.3.10/915/438.5.1.1.44/2026, dated 26 October 2026). Separate parental consent and student assent were not obtained, as the school granted permission on behalf of the students (see Research Limitations). Formal ethical committee approval was not required for this study under the institutional regulations of Universitas Terbuka.

DATA AVAILABILITY

The datasets generated and analyzed during this study are not publicly available because they contain individual test scores of junior high school students, who are minors, and sharing them was not covered by the permission obtained from the school. The summary statistics and results supporting the findings are reported in full within this article.

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