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Knowing and regulating learning: Metacognitive awareness and science achievement among Grade 6 learners in the Philippines

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Abstract

Metacognitive awareness is associated with academic learning, yet evidence from Philippine elementary science remains limited and questionnaire reports cannot be assumed to represent effective strategy use. This cross-sectional study examined the relationship between self-reported metacognitive awareness and classroom science achievement among 169 Grade 6 learners in one multilingual Philippine public school. Metacognition was measured with a Filipino translation of the 18-item Junior Metacognitive Awareness Inventory, Version B; achievement was the exact mean of three quarterly science grades. The inventory showed acceptable internal consistency for the overall score (α = .824), knowledge of cognition (α = .708, ω = .710), and regulation of cognition (α = .705, ω = .708). Mean science achievement was 84.65 (SD = 5.13), and 86.39% of learners attained at least a satisfactory classroom grade. Achievement correlated positively with overall metacognitive awareness, r = .474, 95% CI [.348, .583], knowledge, r = .496, 95% CI [.373, .602], and regulation, r = .375, 95% CI [.237, .498] (all p < .001). The knowledge correlation exceeded the regulation correlation, Williams's t(166) = 2.23, p = .027. Welch tests likewise identified achievement-group differences in overall awareness, F(3, 62.45) = 22.11, knowledge, F(3, 61.81) = 24.72, and regulation, F(3, 62.99) = 11.89 (all p < .001). The study contributes context-specific evidence that learners' perceived knowledge of cognition may align more closely with classroom achievement than perceived regulation. Because the design was cross-sectional and used self-reports and locally assigned grades, the findings indicate association rather than demonstrated strategy effectiveness or causation.

Introduction

Science learning requires more than the recall of facts. Learners must interpret representations, connect evidence with explanations, monitor whether they understand a problem, and decide whether a strategy is appropriate for a task. These demands make metacognition—knowledge about cognition and the regulation of cognition—relevant to science learning (Flavell, 1979; Schraw & Dennison, 1994; Stanton et al., 2021). Metacognition also intersects with self-regulated learning because learners translate goals and monitoring judgments into strategic action; recent developmental research further links these processes with engagement, motivation, and learning outcomes (Chen et al., 2025; Katsantonis, 2024; Wang et al., 2021). However, metacognitive awareness is often measured by self-report. Such measures capture learners' perceptions of what they know and do, not the accuracy or quality of strategy enactment during an actual science task (Craig et al., 2020; de Araujo et al., 2025).

Knowledge and regulation of cognition

Knowledge of cognition concerns what learners understand about themselves, strategies, and the conditions under which strategies may be useful. Regulation of cognition concerns the actions used to plan, manage, monitor, and evaluate learning (Schraw & Dennison, 1994). The Junior Metacognitive Awareness Inventory, Version B (JrMAI-B), operationalizes these broad components for learners in

Grades 6–9 through 18 self-report items (Sperling et al., 2002). Its intended item assignments comprise nine knowledge items and nine regulation items. Subsequent psychometric research has continued to examine its structure, underscoring that users should not automatically treat narrow item clusters as independently validated subscales (Kim et al., 2017).

The adult Metacognitive Awareness Inventory distinguishes declarative, procedural, and conditional knowledge and planning, information management, monitoring, and evaluation. These concepts are pedagogically useful, but JrMAI-B was developed principally around the broader knowledge and regulation components. Accordingly, overall awareness, knowledge of cognition, and regulation of cognition are treated as the primary outcomes. Seven adult-MAI-derived item groupings are reported only as exploratory descriptions and are not presented as validated JrMAI-B subscales.

Self-report, domain specificity, and the perception–performance gap

Self-reports are practical for large groups and provide access to learners' beliefs about processes that are not directly observable. Nevertheless, systematic evidence shows that offline questionnaires may correspond imperfectly with online monitoring, observed strategy use, or task performance (Craig et al., 2020). Accurate monitoring depends on the quality of learners' judgments about what they know, whereas control depends on whether those judgments lead to appropriate strategic decisions (Koriat, 1997; Pressley & Ghatala, 1990). Performance-based measures can also predict outcomes differently from self-reports (de Araujo et al., 2025). High questionnaire scores therefore mean that learners endorsed metacognitive statements frequently; they do not demonstrate accurate calibration or effective strategy production.

This distinction is especially important in science because metacognition is partly situated in the concepts, representations, and epistemic demands of a domain (Willison, 2024). A learner may know that monitoring is valuable while failing to monitor evidence, variables, or explanations effectively during inquiry. Recent school-based studies indicate that metacognitive questioning and prompts can support biology or digital learning when embedded in substantive tasks (Sadykova et al., 2024; Zeitlhofer et al., 2023). Work in primary inquiry-based science further distinguishes the availability of self-regulated-learning strategies from their production during inquiry and supports domain-specific assessment when actual science regulation is the target (Sins et al., 2025). The JrMAI-B was retained here because the study concerned general learning awareness among Grade 6 learners and because its brevity and developmental suitability supported school administration. Its domain-general scope is nevertheless a limitation: the study cannot determine how effectively participants enacted these strategies during science inquiry.

Philippine context and research problem

Grade 6 is the final year of Philippine elementary education and precedes transition to junior high school. The national curriculum expects learners to work with increasingly complex scientific ideas and practices. At the same time, national performance must not be inferred from one school's classroom grades. In PISA 2022, only 23% of participating Filipino 15-year-olds attained at least Level 2 in science, although the age and assessment design differ from the present Grade 6 sample (OECD, 2023). Research profiling low-proficiency Filipino science learners likewise illustrates the heterogeneity and contextual complexity of science performance (Bernardo et al., 2023). These findings motivate careful separation of classroom grades, questionnaire perceptions, and standardized proficiency.

The study was conducted in a multilingual public-school setting. Filipino translation was used to reduce avoidable language barriers when learners reflected on their learning. Translation improves comprehensibility but does not eliminate response bias, overconfidence, or the difference between perceived and demonstrated regulation. The resulting scores are therefore interpreted as self-reported awareness rather than verified metacognitive performance.

Conceptual framing and contribution

Figure 1 summarizes the study's measurement-conscious conceptual framing. The solid arrows represent the two tested associations between self-reported JrMAI-B components and classroom science achievement. The variable subtitles distinguish the self-report scores from the mean of three quarterly classroom grades, while the dashed arrows identify plausible shared influences that were not measured or estimated as causal pathways. The model therefore guides interpretation rather than asserting that knowledge or regulation produces higher grades.

The intended contribution is consequently specific. Rather than re-establishing only that metacognition and achievement are related, the study compares the two broad JrMAI-B components in an underrepresented multilingual Philippine Grade 6 setting, tests whether their correlations with exact classroom grades differ, and interprets the results through the distinction between perceived awareness and demonstrated strategy use.

Purpose and research questions

This study examined how Grade 6 learners' self-reported metacognitive awareness was associated with their classroom science achievement. It addressed the following questions:

1. What was the distribution of learners across classroom science-achievement levels?
2. What were the levels and internal consistency of overall JrMAI-B, knowledge-of-cognition, and regulation-of-cognition scores?
3. Did the primary JrMAI-B scores differ across science-achievement groups?

4. How were the primary JrMAI-B scores associated with exact numerical science grades?
5. As an exploratory analysis, how were seven adult-MAI-derived item groupings descriptively related to science grades?

Because all variables were observed at one time and no intervention was introduced, the study tests associations and group differences. It does not test whether metacognition causes achievement or whether any instructional strategy is effective.

Methodology

Design and setting

A quantitative, cross-sectional correlational design was used because the study sought to describe learners' metacognitive-awareness scores and examine how those scores varied with science achievement at a single period in Grade 6. No variable was manipulated and no instructional intervention was introduced; the design therefore supports estimates of contemporaneous association and achievement-group differences, but not causal or developmental conclusions.

Data were collected during the 2025–2026 school year in one public elementary school in Iligan City, Philippines. The school served learners in regular elementary classes and a Special Science Elementary School program, providing a locally relevant setting in which Grade 6 science learning and metacognitive awareness could be examined. The school is not named to preserve institutional and participant confidentiality. Because the study involved one school, its estimates describe this setting and are not intended to represent all Philippine Grade 6 learners.

Participants and sampling

The source population comprised all 293 Grade 6 learners enrolled in the participating school. Systematic selection was implemented from official class lists across the Grade 6 sections so that recruitment was distributed throughout the cohort rather than concentrated in a single classroom. Approximately every second listed learner was approached until the study obtained 169 participants with written parent or guardian permission, learner assent, an answered JrMAI-B questionnaire, and three available quarterly science grades. The analytical sample represented 57.7% of the Grade 6 population, and all 169 records contained the variables required for the principal analyses.

For the primary correlation analyses, the achieved sample of 169 provided 80% power at a two-sided α of .05 to detect an association of approximately $|r| = .214$ or larger. This sensitivity estimate indicates that the study was equipped to identify small-to-moderate linear relationships in this school cohort; it does not imply equivalent precision for every subgroup or exploratory item grouping.

Measures

JrMAI-B

Metacognitive awareness was measured with the 18-item Junior Metacognitive Awareness Inventory, Version B (JrMAI-B), which was developed for older elementary and early secondary learners (Sperling et al., 2002) and was therefore appropriate to the developmental level of the Grade 6 participants. Learners responded from 1 (never) to 5 (always). The scoring key does not designate any reverse-scored item, including Item 16. Knowledge of cognition comprised Items 1, 2, 3, 4, 5, 12, 13, 14, and 16; regulation of cognition comprised Items 6, 7, 8, 9, 10, 11, 15, 17, and 18. Each component score was the arithmetic mean of its nine items, and overall metacognitive awareness was the mean of all 18 items. Scores ranged from 1 to 5, with higher values indicating more frequent endorsement of statements about knowing and regulating one's learning.

To make the instrument understandable within the multilingual school context, the English JrMAI-B was translated into Filipino using conceptual rather than word-for-word equivalence. The instrument underwent validation by five experts in the field before administration, and their review informed the suitability of the wording for the intended learners and study setting. The language review considered accuracy, clarity, naturalness, and age appropriateness, after which the questionnaire wording was finalized for Grade 6 administration.

A separate pre-administration pilot reliability dataset was not available. Internal consistency was therefore evaluated in the 169-participant study sample using Cronbach's alpha and one-factor McDonald's omega for knowledge of cognition and regulation of cognition. Alpha was also reported for the complete 18-item score. The overall one-factor omega is presented cautiously because JrMAI-B is conceptually organized around two related components. A confirmatory factor analysis of the Filipino version was not conducted; consequently, the study does not claim that its factorial structure was established in this sample.

Additional diagnostics examined how the Filipino items functioned in this Grade 6 sample. These comprised corrected item–total correlations, alpha if an item was deleted, 2,000-resample percentile confidence intervals for alpha and one-factor omega, and the correlation between the two component means. Parallel analysis compared the observed correlation-matrix eigenvalues with the 95th percentile from 1,000 random datasets of the same dimensions. A two-factor exploratory factor analysis with varimax rotation was used only as a structural sensitivity analysis. Given the sample size and the exploratory, non-preregistered nature of this analysis, it was not treated as a validation study. Item 16 was also reverse-scored in a sensitivity check to evaluate whether that alternative improved measurement performance; the primary scoring retained the positively keyed response direction.

Seven item-grouping means were examined only to generate more specific hypotheses about the Grade 6 responses: declarative knowledge (Items 1, 4, 12), conditional knowledge (Items 2, 5, 13, 14), procedural knowledge (Items 3, 16), information management (Items 6, 11), evaluation (Items 7, 17), monitoring (Items 8, 10, 15), and planning (Items 9, 18). Because each grouping contained only two to

four items and a seven-factor structure was not established, these scores were treated as exploratory descriptions rather than validated JrMAI-B subscales.

Science achievement

Science achievement was operationalized as the arithmetic mean of each learner's official first-, second-, and third-quarter science grades. Using three grading periods reduced dependence on a single-quarter result and aligned the outcome with the learners' sustained classroom performance during the school year. The unrounded mean was used for correlations and achievement-group assignment. Intervals followed the Philippine classroom descriptors: <75, did not meet expectations; 75 to < 80, fairly satisfactory; 80 to < 85, satisfactory; 85 to < 90, very satisfactory; and ≥ 90, outstanding (Department of Education, 2015).

Within Philippine classroom assessment, science grades may combine written work, performance tasks, and quarterly assessments. The study records contained the finalized quarterly grades needed to calculate each learner's three-quarter mean, but not the underlying task scores, teacher-level weighting decisions, moderation records, or competency-level results. Science achievement is therefore interpreted as locally assigned classroom performance across three quarters rather than a standardized estimate of national science proficiency or a direct measure of inquiry-strategy use.

Data-collection procedure

Figure 2 presents the sequence used to collect and integrate the study data. After administrative authorization, the researchers coordinated with Grade 6 personnel and applied systematic selection to the official class lists. Parent or guardian information and consent materials were distributed to selected learners, and age-appropriate assent was obtained before participation. These steps ensured that recruitment covered the Grade 6 sections while preserving voluntary participation.

The Filipino JrMAI-B was administered as a printed questionnaire using the same instructions for participating learners. They were told that the activity was not an examination, participation was voluntary, and their responses would not affect their science grades. The authorized first-, second-, and third-quarter grades were then extracted from school records. Questionnaire and grade records were linked only through study codes, checked for completeness and allowable values, and organized as one deidentified record per learner for analysis.

Ethical considerations

Administrative authorization was obtained from the Schools Division Superintendent and school principal. Before any study procedures began, written informed consent was obtained from the parent or legal guardian of every participating learner. Each learner also provided written, age-appropriate assent; no learner was enrolled without both guardian consent and learner assent. Participation was voluntary, withdrawal carried no academic penalty, and questionnaire responses did not affect school grades. Names were replaced by study codes, the linkage file was stored separately with restricted access, and

only aggregate results are reported. Personal and academic information was handled in accordance with the Philippine Data Privacy Act of 2012.

Statistical analysis

The analytical dataset contained one deidentified record for each of the 169 participating learners, including the 18 JrMAI-B item responses and the three quarterly science grades. Item responses were checked against the 1–5 response scale, grade values were checked against their allowable range, and component and overall scores were calculated using the scoring rules described above. Frequencies and percentages summarized the achievement categories; means, standard deviations, ranges, and 95% confidence intervals summarized continuous JrMAI-B and science-grade measures.

Internal consistency was estimated with alpha and omega. Distributional assumptions were examined using Shapiro–Wilk tests, skewness, kurtosis, boxplots, and interquartile-range outlier flags. These checks were used to understand the sample distributions and select appropriate sensitivity analyses, not to remove observations automatically. The few flagged values remained within the permitted score ranges and were retained because they represented plausible learner responses and grades.

Because the study compared JrMAI-B scores across the locally defined achievement categories, variance equality was assessed before group inference. Levene's tests indicated unequal variances for overall metacognition, knowledge of cognition, and regulation of cognition. Welch's one-way ANOVA with Satterthwaite denominator degrees of freedom was therefore used, followed by Games–Howell pairwise comparisons, which do not require equal group variances or equal sample sizes. Classical η^2 and ω^2 are presented as descriptive estimates of between-group separation rather than as fixed labels of practical importance.

Pearson correlations quantified associations between exact numerical science grades and primary JrMAI-B scores. Results include 95% confidence intervals and r^2 as statistical overlap. Spearman correlations were calculated as a sensitivity analysis because the score distributions departed modestly from normality. The two correlations sharing science achievement were compared with Williams's test, which accounts for the correlation between knowledge and regulation. All tests were two-tailed at $\alpha = .05$. With the exception of conventional symbols, exact p values are reported; p values smaller than .001 are shown as $p < .001$.

Results

Data completeness and science achievement

All 169 learners contributed complete JrMAI-B responses and three quarterly science grades to the principal analyses. The mean of the three quarterly grades was 84.65 (SD = 5.13, 95% CI [83.87, 85.42]), with learner averages ranging from 76.00 to 96.67. Table 1 places these continuous averages within the Philippine classroom-achievement intervals used in the study.

Table 1
Distribution of learners by exact science-achievement interval

Exact interval	Descriptor	n	%
≥ 90	Outstanding	37	21.89
85 to < 90	Very satisfactory	26	15.38
80 to < 85	Satisfactory	83	49.11
75 to < 80	Fairly satisfactory	23	13.61
< 75	Did not meet expectations	0	0.00
—	Total	169	100.00

Note. Percentages use N = 169 and exact, unrounded three-quarter averages. At least satisfactory = 146/169 (86.39%); very satisfactory or outstanding = 63/169 (37.28%).

Nearly half of the sample was classified as satisfactory (83 learners, 49.11%), while 63 learners (37.28%) were very satisfactory or outstanding. A further 23 learners (13.61%) were fairly satisfactory, and none had an average below 75. Thus, 146 learners (86.39%) were at least satisfactory within the school's grading framework. These proportions characterize locally assigned classroom grades and should not be compared directly with PISA or other standardized proficiency estimates, which use different tasks, scales, and populations.

Primary JrMAI-B scores and reliability

Table 2
Descriptive statistics and internal consistency of primary JrMAI-B scores

Score	Items	M	SD	95% CI for M	α	ω
Overall metacognitive awareness	18	3.757	0.540	[3.675, 3.839]	0.824	0.826
Knowledge of cognition	9	3.771	0.580	[3.682, 3.859]	0.708	0.710
Regulation of cognition	9	3.743	0.598	[3.652, 3.834]	0.705	0.708

Note. Scores range from 1 to 5. Omega values are one-factor estimates. The overall omega is shown cautiously because JrMAI-B contains two related theoretical components.

As shown in Table 2, learners endorsed the JrMAI-B statements relatively frequently, with means near 3.75. These values are questionnaire endorsements and are not interpreted as proof that strategies were accurately enacted during science learning. Internal consistency was acceptable for the intended group-level analyses, although the two component coefficients were close to .70 and should not be overstated.

Bootstrap intervals indicated uncertainty around the reliability estimates: overall α 95% CI [0.777, 0.860] and ω 95% CI [0.778, 0.861]; knowledge α 95% CI [0.626, 0.773] and ω 95% CI [0.615, 0.775]; and regulation α 95% CI [0.626, 0.765] and ω 95% CI [0.620, 0.767]. Corrected item–total correlations ranged from 0.240 to 0.555; deleting any single item produced overall α values from 0.808 to 0.825. Knowledge and regulation were strongly related but nonidentical, r = 0.679, p < .001.

Parallel analysis narrowly retained two factors: the second observed eigenvalue was 1.589, compared with a random-data 95th-percentile value of 1.585. However, the exploratory rotated loadings did not reproduce a fully clean knowledge-versus-regulation pattern; several items cross-loaded and at least one regulation item loaded more strongly with the mixed first factor. The result is compatible with two broad components but is not sufficient to claim factorial validation of the Filipino translation. The Item 16 sensitivity analysis supported positively keyed scoring: reverse-scoring reduced knowledge α from 0.708 to 0.619 and changed its corrected item–total correlation from 0.240 to -0.240.

Taken together, the evidence in Table 2 and the item diagnostics supports using the overall, knowledge, and regulation means for sample-level comparisons. It does not justify treating a learner's score as a clinical or diagnostic classification. The two components were strongly related but not identical, which supports reporting their associations with science achievement separately while maintaining caution about fine-grained individual interpretation.

Achievement-group comparisons

Table 3
Primary JrMAI-B scores by science-achievement group

Score	Fairly satisfactory n = 23	Satisfactory n = 83	Very satisfactory n = 26	Outstanding n = 37
Overall metacognition	3.309 (0.677)	3.647 (0.506)	3.938 (0.319)	4.155 (0.287)
Knowledge of cognition	3.271 (0.664)	3.647 (0.529)	3.940 (0.384)	4.240 (0.346)
Regulation of cognition	3.348 (0.749)	3.647 (0.616)	3.936 (0.371)	4.069 (0.327)

Note. Entries are M (SD). Group assignment used exact, unrounded science-grade means.

Table 4
Welch's ANOVA comparisons across achievement groups

Outcome	Levene W	p	Welch F	df1	df2	p	η²	ω²
Overall metacognition	8.769	< .001	22.108	3	62.45	< .001	0.252	0.237
Knowledge of cognition	5.030	.002	24.723	3	61.81	< .001	0.282	0.267
Regulation of cognition	6.942	< .001	11.892	3	62.99	< .001	0.154	0.138

Note. Welch's ANOVA is the primary inferential test because all three Levene tests were significant. η² and ω² are descriptive group-effect estimates.

Table 3 shows an ordered increase in all three JrMAI-B scores across the achievement categories. Mean overall metacognitive awareness rose from 3.309 in the fairly satisfactory group to 4.155 in the outstanding group. Knowledge of cognition increased from 3.271 to 4.240 across the same categories, while regulation of cognition increased from 3.348 to 4.069. The pattern indicates that learners with higher classroom-grade classifications generally reported more metacognitive awareness, although the within-group standard deviations show that individual scores still overlapped.

The Welch tests in Table 4 confirmed differences among the four observed groups for overall metacognitive awareness, $F(3, 62.45) = 22.11$, $p < .001$; knowledge of cognition, $F(3, 61.81) = 24.72$, $p < .001$; and regulation of cognition, $F(3, 62.99) = 11.89$, $p < .001$. The descriptive effect estimates were largest for knowledge of cognition, consistent with the stronger correlation reported below. These tests establish separation among sample means but do not identify a causal direction between metacognitive awareness and achievement.

Table 5
Significant Games–Howell pairwise comparisons

Outcome	Group 1	Group 2	Mean difference	95% CI	Adjusted p
Overall metacognition	Fairly satisfactory	Very satisfactory	-0.629	[-1.049, -0.209]	.002
Overall metacognition	Fairly satisfactory	Outstanding	-0.845	[-1.253, -0.438]	< .001
Overall metacognition	Satisfactory	Very satisfactory	-0.291	[-0.512, -0.071]	.005
Overall metacognition	Satisfactory	Outstanding	-0.508	[-0.698, -0.318]	< .001
Overall metacognition	Very satisfactory	Outstanding	-0.217	[-0.425, -0.008]	.038
Knowledge of cognition	Fairly satisfactory	Very satisfactory	-0.670	[-1.095, -0.244]	< .001
Knowledge of cognition	Fairly satisfactory	Outstanding	-0.970	[-1.377, -0.562]	< .001
Knowledge of cognition	Satisfactory	Very satisfactory	-0.294	[-0.545, -0.042]	.016
Knowledge of cognition	Satisfactory	Outstanding	-0.594	[-0.806, -0.381]	< .001
Knowledge of cognition	Very satisfactory	Outstanding	-0.300	[-0.551, -0.049]	.013
Regulation of cognition	Fairly satisfactory	Very satisfactory	-0.588	[-1.056, -0.121]	.009
Regulation of cognition	Fairly satisfactory	Outstanding	-0.721	[-1.173, -0.269]	< .001
Regulation of cognition	Satisfactory	Very satisfactory	-0.289	[-0.551, -0.028]	.024
Regulation of cognition	Satisfactory	Outstanding	-0.422	[-0.648, -0.197]	< .001

Note. Mean difference = Group 1 minus Group 2. All p values are multiplicity-adjusted by the Games–Howell procedure. Nonsignificant pairs are available in the statistical-output file.

Table 5 identifies where the group differences occurred after adjustment for multiple pairwise testing. For overall metacognition and knowledge of cognition, the very satisfactory and outstanding groups each exceeded both the fairly satisfactory and satisfactory groups; the outstanding group also exceeded the very satisfactory group. For regulation of cognition, the very satisfactory and outstanding groups each exceeded the two lower groups, but their means did not differ significantly from one another. The

fairly satisfactory and satisfactory groups did not differ significantly on any primary JrMAI-B score. This pattern suggests clearer separation at the upper end of the school achievement distribution than between the two lower categories.

Associations with exact science grades

Table 6
Correlations between primary JrMAI-B scores and science achievement

Score	n	Pearson r	95% CI	p	r^2	Spearman ρ
Overall metacognition	169	0.474	[0.348, 0.583]	< .001	0.225	0.503
Knowledge of cognition	169	0.496	[0.373, 0.602]	< .001	0.246	0.523
Regulation of cognition	169	0.375	[0.237, 0.498]	< .001	0.141	0.411

Note. All correlation tests were two-tailed. Spearman results are sensitivity analyses and were also p < .001.

As summarized in Table 6, science achievement was positively associated with overall metacognitive awareness, r = .474, 95% CI [.348, .583], p < .001, and with both components: knowledge of cognition, r = .496, 95% CI [.373, .602], p < .001, and regulation of cognition, r = .375, 95% CI [.237, .498], p < .001. The corresponding r^2 values indicate statistical overlap of 22.5%, 24.6%, and 14.1%, respectively. These values describe shared variation in this sample; they are not percentages of achievement caused by metacognition and do not constitute individual predictions.

Williams's test showed that the association for knowledge of cognition was stronger than that for regulation of cognition, t(166) = 2.23, p = .027, after accounting for the correlation between the two JrMAI-B components. The Spearman coefficients were similar in direction and magnitude and were all significant at p < .001, indicating that the conclusions were not dependent solely on Pearson's distributional assumptions or a few extreme observations.

Exploratory dimension-level results

Table 7 reports the seven small item groupings as exploratory descriptions intended to generate hypotheses about the Grade 6 response pattern. Because these clusters contain only two to four items and their seven-factor structure was not validated for the Filipino JrMAI-B, they should not be interpreted as established subscales.

Table 7
Exploratory item-grouping descriptions and correlations with science grades

Exploratory grouping	Items	M	SD	r	95% CI	p
Declarative knowledge	1, 4, 12	4.043	0.681	0.441	[0.311, 0.555]	< .001
Conditional knowledge	2, 5, 13, 14	3.723	0.697	0.461	[0.333, 0.572]	< .001
Procedural knowledge	3, 16	3.456	0.779	0.259	[0.113, 0.395]	< .001
Information management	6, 11	3.754	0.890	0.360	[0.221, 0.485]	< .001
Evaluation	7, 17	3.571	0.815	0.203	[0.053, 0.343]	.008
Monitoring	8, 10, 15	3.686	0.726	0.262	[0.116, 0.397]	< .001
Planning	9, 18	3.988	0.864	0.275	[0.129, 0.409]	< .001

Note. Exploratory only; these clusters are not claimed to be validated JrMAI-B subscales. No dimension ranks or categorical "high awareness" labels are used.

All seven exploratory groupings were positively associated with science grades, with Pearson correlations ranging from .203 for evaluation to .461 for conditional knowledge. Conditional knowledge (r = .461) and declarative knowledge (r = .441) had the largest estimates, whereas the remaining groupings showed smaller associations. Because the clusters contain few items and were not established as distinct factors, differences among these coefficients are descriptive and should not be interpreted as a validated ranking of metacognitive dimensions.

Discussion

The analysis yielded three central findings. First, learners reported relatively frequent endorsement of JrMAI-B statements, and the Filipino scores showed acceptable, although not strong, internal consistency for group-level research. Second, exact classroom science grades were positively associated with overall awareness and with both theoretical components. Third, knowledge of cognition showed a stronger association with achievement than regulation of cognition. Together, the findings extend the literature by locating a familiar metacognition–achievement relationship within an underrepresented Grade 6 Philippine public-school setting while also showing that the two broad JrMAI-B components should not be treated as interchangeable. This contribution is contextual and comparative rather than causal: it concerns how perceived knowledge and regulation covary with locally assigned science grades.

Interpreting self-reported awareness

The mean scores near 3.75 indicate that learners commonly endorsed statements about knowing and regulating their learning. They do not show that learners accurately monitored understanding or effectively produced strategies during science tasks. Recent measurement evidence shows that questionnaire and performance-based indicators can represent different aspects of metacognition and can predict achievement differently (de Araujo et al., 2025). Self-report estimates can reflect beliefs, familiarity with desirable learning behaviours, social desirability, or confidence as well as actual practice (Craig et al., 2020). The present pattern is therefore consistent with a possible perception–performance gap: learners may recognize desirable strategies and describe themselves as using them without consistently deploying those strategies at the appropriate time or evaluating their success accurately.

Developmental considerations also matter. Recent studies show that metacognitive development is associated with learning outcomes from early childhood onward and remains responsive to motivational and classroom conditions (Dutemple et al., 2024; Opdenakker, 2022). By late elementary school, learners can articulate aspects of their cognition, but strategic knowledge, monitoring accuracy, and independent control do not necessarily mature at the same rate. JrMAI-B responses may consequently combine emerging metacognitive understanding with confidence, vocabulary, and familiarity with classroom expectations. The acceptable but modest component reliabilities reinforce the need to interpret individual differences cautiously. The instrument is useful for estimating group-level perceived awareness, but it should not be used as a diagnostic substitute for observations, think-aloud evidence, calibration tasks, or traces of strategy use.

The high proportion of satisfactory classroom grades does not contradict national science-performance concerns. Classroom grades aggregate curriculum-based tasks and local grading practices, whereas PISA uses standardized tasks with a different age group and inferential target (OECD, 2023). The present data neither confirm nor refute national proficiency patterns. They show only that, within one school's grading system, learners with higher grades tended to report greater metacognitive awareness.

Knowledge and regulation in relation to achievement

Knowledge of cognition shared approximately 24.6% of observed variance with science grades, compared with 14.1% for regulation. Williams's test indicated that the difference between these dependent correlations was statistically distinguishable in this sample. The result challenges a simple expectation that reported regulation must be the stronger correlate of achievement. Knowledge items may align more closely with what classroom assessment rewards: awareness of existing understanding, recognition of task demands, and knowledge of when a familiar strategy is appropriate. Recent evidence similarly treats metacognitive knowledge and self-regulation as related but distinguishable resources whose expression varies with age, motivation, and task context (Katsantonis, 2024; Toikka et al., 2024).

The weaker regulation correlation has at least three plausible explanations. First, regulation is more execution-dependent: planning or monitoring matters only if it is appropriately timed and adapted to the

science task. Second, retrospective questionnaire judgments may be less sensitive to the quality of regulation than to learners' declarative beliefs about themselves. Third, classroom grades may capture completed products more reliably than the monitoring and revision processes that produced them. Recent science-education syntheses and interventions likewise emphasize that metacognitive activity becomes meaningful when tied to domain-specific inquiry, explanation, and evidence evaluation (Sadykova et al., 2024; Sins et al., 2025; Willison, 2024). These explanations are complementary and should be tested directly rather than inferred from the correlations alone.

Neither component can be assigned a causal role from the present design. Higher awareness may facilitate achievement, but successful performance can also strengthen confidence and retrospective reports of strategy use. Both may arise from prior science knowledge, reading and language proficiency, motivation, self-efficacy, attendance, family resources, classroom climate, teacher feedback, or exposure to cognitively demanding instruction. Recent evidence links metacognition with academic outcomes but also shows that associations vary with age, domain, culture, motivation, and measurement (Katsantonis, 2024; Musullulu et al., 2025; Xie et al., 2024). The observed r^2 values are therefore statistical overlap, not percentages of grades caused by metacognition.

The positive associations are broadly consistent with science-education research connecting metacognitive variables with achievement, including models that place metacognition alongside epistemic beliefs and school achievement context (Acar, 2022). They are also compatible with evidence that metacognitive instruction can improve science outcomes (Antonio & Prudente, 2021). However, intervention effects and cross-sectional correlations answer different questions. The present study did not manipulate instruction, observe change, or establish that learners with higher questionnaire scores benefited from a particular metacognitive practice. Its evidential contribution is therefore the component-specific association in this local population, not confirmation of an instructional effect.

Achievement-group differences

Welch's tests and Games–Howell comparisons showed that the observed achievement groups differed on all three primary scores. The use of robust tests was important because variances and group sizes were unequal. Most significant comparisons involved the outstanding or very satisfactory groups relative to lower groups. Nevertheless, the categories are transformations of the same grade variable used in the correlations; group differences should not be treated as independent replication of the correlational findings. Categorization also discards information, so the continuous correlations remain the more informative primary evidence.

The increasing group means may nevertheless have practical descriptive value. They suggest that the association was not driven solely by a few extreme observations and that learners in the highest local grade category also tended to describe themselves as more knowledgeable and regulatory. At the same time, overlap remained within every category, so a learner's JrMAI-B score cannot determine an

achievement classification. Because categories were created from the same continuous grades, the pairwise results clarify where sample means differed but do not add a separate causal or predictive test.

Exploratory dimensions

All seven exploratory item clusters correlated positively with grades, but their estimates varied. Declarative and conditional groupings showed the largest correlations, while evaluation showed the smallest. These patterns may guide future hypotheses, but the clusters contain few items and were not confirmed as seven factors. The results should therefore not support claims that Grade 6 learners possess seven distinct, reliably measured levels of metacognitive awareness. A future Filipino validation study should use adequately powered factor analysis, cognitive interviewing, test–retest reliability, and measurement-invariance testing before dimension-level claims are emphasized.

Educational implications

The results justify assessment and instructional questions, not a claim that a particular intervention works. Teachers may invite learners to identify what they already know, predict where difficulty may occur, explain why a strategy fits a task, monitor evidence during investigations, and evaluate whether conclusions follow from observations. These practices translate metacognition into observable science activity. Recent evidence supports modelling, prompts, questioning, and structured reflection, while indicating that their effectiveness depends on integration with subject content and guided practice (Sadykova et al., 2024; Stanton et al., 2021; van Loon et al., 2021; Zeitlhofer et al., 2023).

A useful classroom implication is therefore triangulation. A brief self-report can initiate conversation about how learners perceive their learning, while task-specific prompts, work samples, observation, and monitoring judgments can show whether those perceptions correspond with performance. Recent comparisons of metacognitive-regulation measures reinforce the value of using more than one measurement approach (Zepeda & Nokes-Malach, 2023). Teachers should avoid labelling pupils as inherently ‘high’ or ‘low’ in metacognition from a single questionnaire. Instead, the results can inform formative questions: Does the learner recognize what the task requires? Can the learner justify a strategy choice? Does monitoring detect an error? Does evaluation lead to revision? Domain-specific evidence should accompany self-report when the aim is to determine whether learners actually regulate inquiry (Sins et al., 2025).

Science-specific metacognitive guidance can also be attached to concrete curricular decisions rather than presented as generic advice. For example, recent biology research has used metacognitive guidance to help learners articulate and evaluate scientific principles (Zion & Cohen, 2021). In the present context, comparable prompts could be incorporated into evidence evaluation, explanation construction, or post-investigation reflection, but their effects would need to be tested rather than assumed from the correlational findings.

Limitations

Several limitations bound the interpretation of the findings. The sample came from one public elementary school, which limits transferability to other schools, regions, programs, and linguistic or socioeconomic groups. The cross-sectional design establishes contemporaneous association but cannot determine temporal direction or causality. Prior science knowledge, motivation, self-efficacy, language proficiency, attendance, socioeconomic resources, classroom climate, teacher feedback, and instructional exposure were not modelled and may contribute to both questionnaire responses and grades. The achievement categories were also unequal in size. Although Welch and Games–Howell procedures reduced dependence on equal variances, the categories were derived from the same continuous grade variable and should not be viewed as an independent replication of the correlation results.

Measurement constraints are equally important. JrMAI-B is a domain-general self-report instrument and does not directly measure strategy production, calibration accuracy, or regulation during science inquiry. The Filipino translation underwent language review, but no separate pilot study or confirmatory factorial validation was available. The new bootstrap intervals, item diagnostics, and parallel analysis provide useful internal evidence, yet the component reliabilities remain modest and the exploratory two-factor loadings were not fully clean. These analyses therefore support cautious use of the broad scores for group-level research rather than diagnostic or definitive structural claims. The seven narrow item clusters contain only two to four items and remain exploratory.

Finally, science achievement was represented by finalized classroom grades. The source file did not include written-work, performance-task, quarterly-assessment, teacher, moderation, or competency-level records needed to audit grade construction. Classroom marks may combine multiple assessment types and professional judgments and are not equivalent to a standardized measure of science proficiency. These limitations do not invalidate the observed associations, but they restrict the conclusion to perceived metacognitive awareness and locally assigned science achievement in this particular setting.

Future research

Multi-school longitudinal studies should combine self-report with observations, think-aloud protocols, inquiry logs, monitoring judgments, and standardized or researcher-developed science tasks. Designs that measure prior science knowledge, language proficiency, motivation, self-efficacy, and instructional exposure could test competing explanations and estimate the incremental contribution of metacognitive measures. Filipino JrMAI-B research should evaluate factor structure, measurement invariance across language and program groups, test–retest stability, and learners' interpretations of translated items. Intervention studies can then test whether explicit, science-embedded strategy instruction changes calibration, observed regulation, and learning rather than only questionnaire endorsement. Recent studies suggest that instruction is most informative when learners receive opportunities to practice, monitor, and transfer strategies across meaningful tasks (Sadykova et al., 2024; Stanton et al., 2021; van Loon et al., 2021; Willison, 2024).

Conclusion

Among 169 Grade 6 learners, self-reported metacognitive awareness was positively associated with classroom science achievement. Knowledge of cognition showed a stronger relationship with grades than regulation of cognition, and robust group comparisons indicated higher primary JrMAI-B means among higher classroom-achievement categories. These findings support the relevance of how learners perceive their knowledge and regulation, but they do not demonstrate accurate strategy use or a causal effect on achievement.

The study's contribution is therefore specific: it provides reproducible evidence concerning a Filipino translation of the JrMAI-B in one multilingual public-school setting. The findings should be interpreted through the distinction between perceived awareness and demonstrated performance, the domain-general nature of the questionnaire, and the local meaning of classroom grades. Future work should pair self-report with science-specific performance measures and stronger psychometric validation.

Declarations

Data Availability

The deidentified participant-level raw and processed datasets, variable codebook, scoring and transformation specifications, bilingual survey instrument, data-collection protocol, statistical analysis script, and corresponding statistical output are provided as supplementary files accompanying this article. Direct identifiers, the participant identity–study code linkage file, school and class identifiers, signed parental consent and learner assent forms, and institutional authorization records are not shared because they contain confidential information concerning minor participants. These restricted records are retained securely in accordance with applicable institutional and school data-protection requirements.

Ethical approval

Ethical approval for the conduct of this study was granted by the Undergraduate Thesis Panel Committee from the Department of Science and Mathematics Education, College of Education, MSU-IIT. All procedures involving human participants were performed in accordance with the committee's requirements, applicable institutional research-ethics policies, the ethical principles of the Declaration of Helsinki, and relevant Philippine regulations. Before any study procedures began, written informed consent was obtained from the parent or legal guardian of every participating learner. Each learner also provided written, age-appropriate assent; no learner was enrolled without both guardian consent and learner assent. School-level authorization was also obtained before data collection.

Competing interests

The authors declare no competing interests.

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Author Contribution

S.H.B. and M.M.C. contributed to the conceptualization of the study, development of the methodology, investigation, data collection, data curation, and preparation of the original manuscript draft. K.D. supervised the research and contributed to the study methodology and critical review and revision of the manuscript and contributed to the formal statistical analysis, interpretation, and validation of the findings. V.M. and C.M.T. contributed to the methodology, validation, and critical review and revision of the manuscript. All authors reviewed and approved the final version of the manuscript and accept responsibility for the integrity of the work.

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Figures

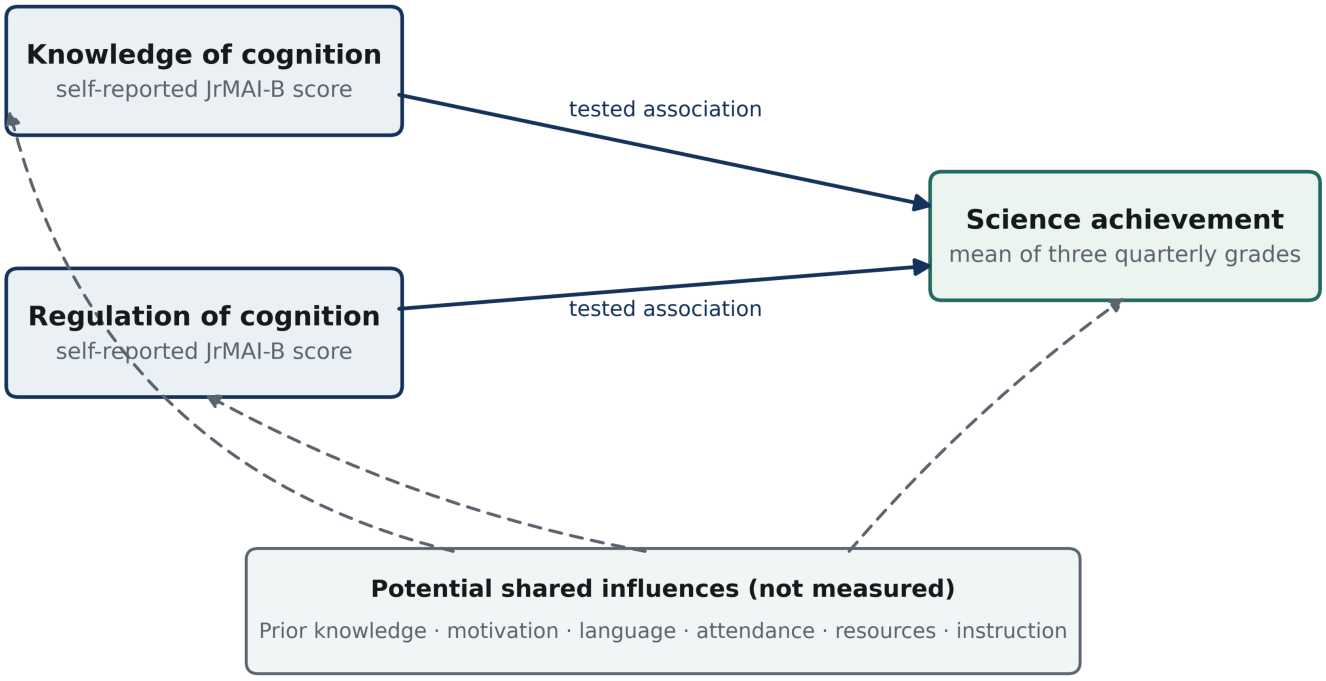


Figure 1

Conceptual model of the tested associations and untested contextual influences

Note: Solid arrows denote associations tested in this study. Dashed arrows denote plausible shared influences that were not measured or estimated as causal paths. JrMAI-B, Junior Metacognitive Awareness Inventory, Version B.

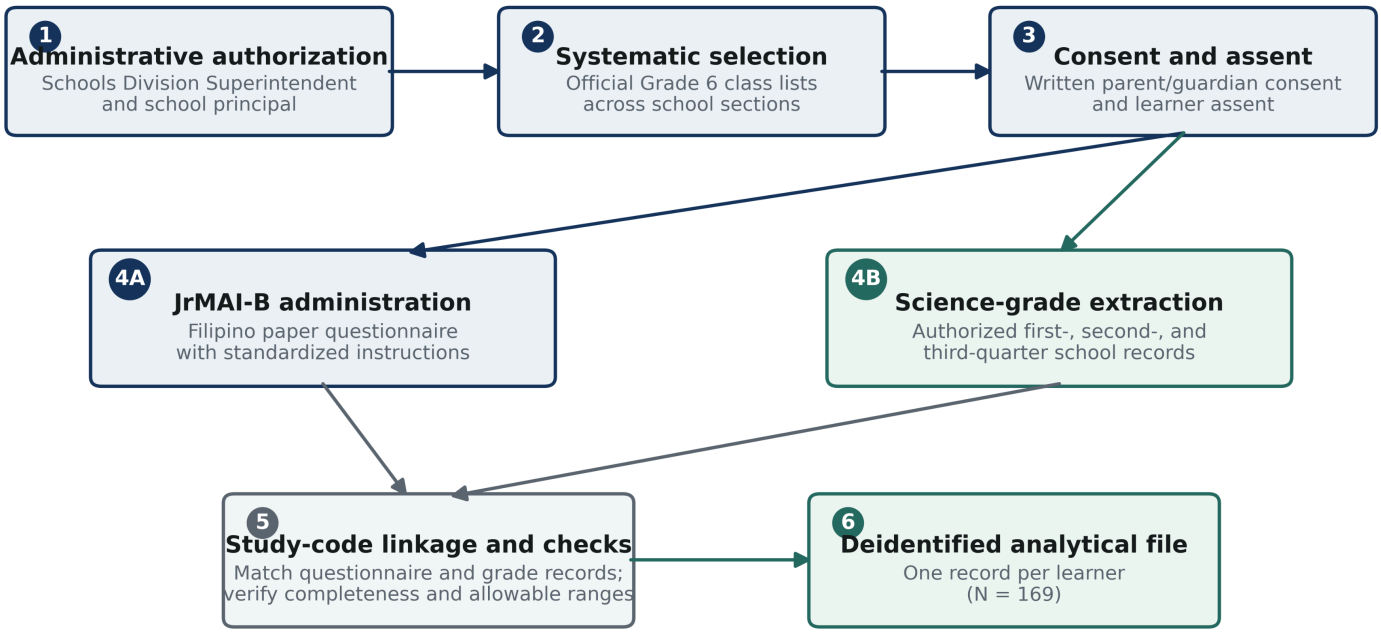


Figure 2

Data-collection and record-integration procedure

Note. JrMAI-B, Junior Metacognitive Awareness Inventory, Version B. The questionnaire responses and authorized quarterly grades were collected as separate sources and linked by study code before analysis.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryData.xlsx
- SurveyandProtocol.docx
- reproduceanalysis.py
- statisticaloutput.txt