

Scientific Reading Processes and Academic Performance Across School Levels: A Comparative Study of Elementary and Junior High School Learners in Batanes, Philippines

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ARTICLE INFORMATION	ABSTRACT
Article history: Published: October 2026	<p>The study compared scientific reading processes and academic performance among elementary and junior high school learners in Batanes, Philippines, and examined whether scientific reading performance was associated with school-record academic outcomes. A quantitative cross-sectional comparative-correlational design was employed with 360 learners: 168 from Grades 5-6 and 192 from Grades 7-10. Scientific reading was measured through a 30-item objective assessment covering vocabulary and concept decoding, evidence retrieval, inferential integration, text-data and diagram integration, and critical evaluation and monitoring. The total assessment demonstrated high internal consistency (KR-20 = 0.914); item difficulty indices ranged from 0.397 to 0.719, and corrected point-biserial correlations ranged from 0.396 to 0.552. Junior high school learners obtained higher scores than elementary learners on the total scientific reading measure (M = 18.26 vs. 15.35; Hedges' g = 0.379, Holm-adjusted p = 0.002). The junior high school group also showed modestly higher general averages and Science grades. Scientific reading total scores correlated strongly with general average (r = 0.714) and Science grade (r = 0.715), both p < .001. These correlations did not differ significantly between school levels. HC3-robust multiple regression indicated that the five reading-process domains jointly explained 52.4% of the variance in general average and 51.4% of the variance in Science grade after school level was included. The findings supported scientific reading as a multidimensional academic competence involving disciplinary vocabulary, inference, coordination of prose with visual data, and critical monitoring. Instructional implications emphasized explicit teaching of science-language patterns, evidence-location routines, causal inference, diagram-text integration, and self-explanation across the elementary-to-secondary transition.</p>
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1. Introduction

Scientific learning is inseparable from reading. Learners encounter science through explanatory prose, definitions, classifications, procedural descriptions, causal accounts, tables, graphs, diagrams, captions, evidence statements, and arguments. Scientific literacy therefore requires more than knowing scientific facts. It also requires the capacity to interpret the specialized forms through which scientific knowledge is represented and communicated. Norris and Phillips argued that literacy in its fundamental sense is central to scientific literacy because science depends on reading and writing as means of constructing, evaluating, and communicating knowledge.⁵ Disciplinary-literacy research similarly showed that expert reading practices differ across subjects; in science, readers must attend closely to technical vocabulary, causal relations, evidence, models, and the relation between claims and data.^{6,7}

This relationship is especially important because science text is linguistically demanding. Fang documented that school science uses grammatical and lexical resources that differ from everyday language, including dense noun groups, technical terms, nominalization, abstraction, and tightly packed logical relations.¹³ A learner may therefore decode the individual words of a science passage yet still fail to construct an adequate representation of the scientific explanation. Difficulty can increase when meaning is distributed across paragraphs, labels, diagrams, tables, and graphs rather than stated in one continuous narrative.

Research on science-text comprehension has identified several cognitive processes that support successful reading. Cromley, Snyder-Hogan, and Luciw-Dubas found that prior-topic knowledge, reading vocabulary, inference, and reading-strategy use made distinct contributions to comprehension of scientific text.⁸ Related work showed that students engaged in high-level cognitive activities when they meaningfully processed complex diagrams, particularly through inference and strategy use.⁹ Ozuru, Dempsey, and McNamara further demonstrated that prior knowledge, reading skill, and text cohesion interact in explaining comprehension of science texts.¹² These findings suggest that scientific reading is best represented as a coordinated set of processes rather than a single general reading skill.

The construction-integration model provides a theoretical explanation for this coordination. Readers first activate propositions and related knowledge and then integrate compatible information into a coherent mental representation.¹⁷ In scientific reading, integration often requires bridging between sentences, linking an unfamiliar term to its definition, relating a diagram to a textual explanation, reconciling evidence with a claim, or using prior knowledge to fill an unstated connection. Text coherence can support

these operations, but its benefit depends partly on the learner's knowledge and strategic capacity.¹⁶ Thus, comprehension is produced by an interaction among reader characteristics, text characteristics, and purposeful cognitive activity.

Multiple representations add another layer. Ainsworth's DeFT framework explained that text, diagrams, graphs, equations, and other representations can complement or constrain one another, but learners must perform cognitive work to connect them.¹⁴ Science materials frequently require exactly this form of representational coordination. A graph may show a trend that the prose only summarizes; a diagram may encode spatial or causal information; a table may contain the evidence needed to evaluate a conclusion. Learners who treat visual representations as decoration rather than as information sources risk missing central scientific meaning.^{9,14} Reading strategy instruction can strengthen these processes. Self-explanation training, for example, prompts readers to explain meaning to themselves, generate inferences, connect ideas with prior knowledge, and repair comprehension when meaning breaks down.¹⁵ Evidence-based adolescent literacy guidance likewise recommends explicit vocabulary and comprehension-strategy instruction, extended discussion of text meaning, attention to motivation, and intensive support for struggling readers.²⁰ Although these recommendations are not limited to science, they are particularly relevant to disciplinary texts whose meaning depends on conceptual language and inferential reasoning.

The connection between reading and academic attainment is well established. Savolainen and colleagues found that written-language skills, including reading comprehension, predicted school achievement and later educational pathways.¹⁹ In science specifically, O'Reilly and McNamara reported that science knowledge, reading skill, and reading-strategy knowledge predicted multiple measures of high school science achievement.¹⁰ Cromley's international analysis of PISA data found very strong associations between reading literacy and science proficiency across countries, supporting the proposition that many of the cognitive resources that enable reading comprehension also support science performance.¹¹

The Philippine context makes this relationship educationally consequential. In PISA 2022, only 24% of Filipino 15-year-old students reached at least Level 2 in reading and 23% reached at least Level 2 in science, while average national performance remained below the OECD average in both domains.⁴ These national data should not be used to infer the performance of any specific school division, but they establish a policy context in which reading and science learning remain closely linked concerns. The results also reinforce the value of examining mechanisms—such as scientific vocabulary, inference, evidence use, and representational integration—that may connect literacy with subject learning.

Philippine curriculum policy also treats assessment as integral to learning. DepEd Order No. 8, s. 2015 defined classroom assessment as a process for tracking and measuring learner progress and for adjusting instruction accordingly.² The MATATAG Curriculum has continued the emphasis on sequenced competencies and disciplinary learning, including Science beginning in the phased implementation of revised grade-level curricula.¹ Within this environment, a scientific-reading assessment can complement classroom grades by revealing how learners process the texts and representations through which much science content is encountered.

Batanes offered a distinct setting for this inquiry. The Philippine Statistics Authority recorded 18,937 persons in the province in the 2024 Census of Population. Batanes comprised six municipalities—Basco, Itbayat, Ivana, Mahatao, Sabtang, and Uyugan—and remained the least populous province in the country.³ The study did not presume that the province's size or island geography caused any particular reading outcome. Rather, the province-wide setting made it possible to examine scientific reading across a compact but geographically distributed school system while preserving representation from both elementary and junior high school levels.

The transition from elementary to junior high school was of particular interest. As learners progress, science texts generally become conceptually denser, vocabulary becomes more specialized, and representations become more compact. Disciplinary-literacy theory predicts that older learners require increasingly specialized ways of reading to meet these demands.^{6,7} At the same time, developmental progression does not guarantee mastery. A learner can advance in grade level while retaining weaknesses in inference, evidence evaluation, or diagram-text integration. Comparing school levels can therefore identify both developmental gains and processes that remain instructionally vulnerable.

Integrated science-literacy instruction offers one response to this challenge. Cervetti and colleagues showed that an integrated approach in upper-elementary classrooms improved science understanding, science vocabulary, and science writing relative to a comparison condition.¹⁸ The implication is not that science time should be converted into generic reading instruction. Instead, literacy can be taught through the actual epistemic work of science: interpreting explanations, using evidence, discussing concepts, writing claims, and coordinating words with representations. This position is consistent with disciplinary-literacy research, which argues for reading practices tailored to the intellectual work of the subject.^{6,7}

Despite the theoretical and empirical connection between reading and science, school-level data often collapse reading into a single achievement score or treat academic grades without examining the processes that may support them. The present study addressed that gap by operationalizing scientific reading through five processes: vocabulary and concept decoding, evidence retrieval, inferential integration, text-data and diagram integration, and critical evaluation and monitoring. It then compared elementary and junior high school learners and examined the relationship of these processes with two school-record outcomes: general academic average and Science grade.

1.1 Objectives of the Study

The study generally examined differences and relationships in scientific reading processes and academic performance among elementary and junior high school learners in Batanes, Philippines. Specifically, it sought to: (1) describe the participants by school level, grade level, sex, and municipality; (2) determine the reliability and item-performance characteristics of the Scientific Reading Process Assessment; (3) determine learners' performance in the five scientific reading domains and in the total assessment; (4) compare elementary and junior high school learners on scientific reading, general academic average, and Science grade; (5) determine the associations between scientific reading processes and the two academic outcomes; (6) test whether the strength of the

scientific reading-academic performance relationship differed between school levels; and (7) determine which scientific reading processes independently explained academic performance after school level was taken into account.

1.2 Research Hypotheses

At the .05 level of significance, the following null hypotheses were tested: H01, elementary and junior high school learners did not significantly differ in scientific reading processes or academic performance; H02, scientific reading processes were not significantly associated with general academic average or Science grade; H03, the association between total scientific reading and academic performance did not differ significantly between elementary and junior high school learners; and H04, the five scientific reading processes did not independently explain academic performance when entered simultaneously with school level.

1.3 Conceptual Framework

The study treated scientific reading as a disciplinary comprehension system. Vocabulary and concept decoding represented the learner's ability to interpret technical terms and concept relations in context. Evidence retrieval referred to locating explicitly stated information, identifying data relevant to a question, and distinguishing central from peripheral details. Inferential integration represented the construction of causal, explanatory, and bridging relations that were not always stated verbatim. Text-data and diagram integration captured coordination across prose, tables, graphs, diagrams, labels, and captions. Critical evaluation and monitoring represented judging whether a conclusion was supported, recognizing inconsistency, and noticing when comprehension required rereading or repair. These processes were expected to operate together, consistent with construction-integration theory, multiple-representation research, and disciplinary-literacy scholarship.^{7,8,14,17}

Academic performance was represented by the learner's general academic average and Science grade obtained from school records for the same grading period. These outcomes were not treated as pure measures of reading. Grades reflect curriculum mastery, written work, performance tasks, and assessment evidence under DepEd classroom-assessment policy.² They were used because they provided ecologically meaningful indicators of school performance against which an independently administered scientific-reading measure could be compared.

2. Methods

A quantitative cross-sectional comparative-correlational design was used. The comparative component examined differences between elementary and junior high school learners, while the correlational component examined the relationship of scientific reading processes with general academic average and Science grade. No experimental treatment was introduced, and the analyses were therefore interpreted as associations rather than causal effects.

The study covered public-school learners in the six municipalities of Batanes. Elementary participants were drawn from Grades 5 and 6, where learners were expected to have moved beyond beginning reading and to engage regularly with informational texts. Junior high school participants were drawn from Grades 7 through 10, where science learning increasingly required specialized terminology, explanation, evidence, and multiple representations. The two-level design supported examination of the elementary-to-secondary transition without combining early primary readers with adolescents.

A priori planning targeted sensitivity to a small-to-moderate standardized school-level difference. For a two-sided independent-groups comparison with effect size $d = .30$, $\alpha = .05$, power = .80, and an allocation ratio approximating the final groups, the required total sample was about 352. The analytic sample contained 360 learners, consisting of 168 elementary learners and 192 junior high school learners. Participants were selected through stratification by school level and municipality, followed by random selection from eligible class lists. This approach preserved representation across both educational levels and across the six municipalities.

The Scientific Reading Process Assessment (SRPA) consisted of 30 objectively scored items, with six items assigned to each of five domains. Items used short science passages, sentence clusters, tables, simple graphs, and labeled diagrams designed for the targeted grade span. Each item had one keyed answer and received one point when correct and zero when incorrect. The total possible score was 30, and each domain score ranged from 0 to 6. The assessment was constructed to sample scientific reading processes rather than to function as a curriculum-content examination; content was therefore limited to broadly accessible science contexts and sufficient information was embedded in the stimulus materials for answering the questions.

Content alignment was reviewed against the conceptual literature on science-text comprehension, disciplinary literacy, inference, vocabulary, and multiple representations.^{5,7,8,9,13,14} The test blueprint required every item to map to one primary reading process and to avoid dependence on specialized factual recall beyond information supplied in the text or visual. Vocabulary items required contextual interpretation rather than dictionary recall; evidence items required locating or selecting relevant information; inference items required connecting propositions; representation items required integrating prose with a diagram, table, or graph; and evaluation items required checking the support for a conclusion or identifying a need for comprehension repair.

Internal consistency of the full assessment was evaluated with Kuder-Richardson Formula 20 because the items were dichotomously scored. The total KR-20 coefficient was 0.914. Domain coefficients ranged from 0.647 to 0.711; these shorter six-item subscales were interpreted with appropriate caution because reliability is partly dependent on test length. Item difficulty indices ranged from 0.397 to 0.719, avoiding an assessment composed predominantly of extremely easy or extremely difficult items. Corrected point-biserial correlations ranged from 0.396 to 0.552, indicating that individual items generally discriminated in the expected direction.

Academic performance was obtained from school records for the corresponding grading period. Two indicators were used: general academic average and Science grade. The school-record approach reduced common-method bias because the predictor assessment and the outcome measures were not derived from the same questionnaire. Grades were interpreted in accordance with the purpose of classroom assessment under DepEd policy—as evidence of learner progress within the curriculum—rather than as standardized scores directly comparable to international assessments.²

Administration was conducted under uniform directions. Learners completed the SRPA in a supervised classroom setting without access to notes, textbooks, or mobile devices. Test administrators used a common script, applied the same time limit, and did not explain item content after testing began. Answer sheets were checked for completeness and scored using the fixed key. Academic grades were matched through coded identifiers and then separated from personally identifying information before analysis.

The analysis proceeded in stages. Frequencies and percentages described the participant distribution. KR-20, item difficulty, and corrected point-biserial coefficients evaluated measurement quality. Means and standard deviations summarized domain scores, total SRPA score, general average, and Science grade. Elementary and junior high school groups were compared using Welch's independent-samples *t* test because it does not require equal group variances. Because eight related between-level comparisons were conducted, Holm adjustment controlled the familywise error rate. Hedges' *g* quantified standardized effect size, with the sign defined so that positive values indicated higher junior high school scores.

Pearson correlations quantified linear associations between scientific reading and the two academic outcomes. The total-score correlations were computed overall and separately by school level. Fisher *r*-to-*z* tests examined whether elementary and junior high school correlations differed significantly. Multiple linear regression then estimated the unique contribution of the five reading domains to each academic outcome with school level included as a covariate. HC3 heteroscedasticity-robust standard errors were reported. Variance inflation factors were examined for multicollinearity, and interaction models tested whether the slope linking total scientific reading with academic performance changed by school level. Statistical significance was set at $\alpha = .05$, but effect sizes, confidence in measurement, and substantive interpretation were considered alongside *p* values.

Ethical safeguards included voluntary participation, learner assent and parent or guardian permission where required, confidentiality, and the use of coded records. Participation or nonparticipation did not affect grades, access to instruction, or school services. The scientific-reading assessment was administered for research purposes and was not used to rank schools or to make high-stakes decisions about individual learners. This was consistent with DepEd's caution that assessment results should be interpreted within context rather than used mechanically to rank schools.²

3. Results

The results are presented according to the study objectives, beginning with participant characteristics and measurement evidence, followed by school-level comparisons, bivariate relationships, cross-level tests of correlation strength, and multivariable models.

Table 1. Participant distribution by school level, grade level, and sex

Characteristic	n	%
Elementary	168	46.7
Junior High School	192	53.3
Grade 5	72	20.0
Grade 6	96	26.7
Grade 7	44	12.2
Grade 8	50	13.9
Grade 9	52	14.4
Grade 10	46	12.8
Female	183	50.8
Male	177	49.2

The analytic sample contained 360 learners, with 46.7% from the elementary level and 53.3% from junior high school. The grade distribution was intentionally spread across Grades 5 through 10 rather than concentrated in a single transition grade. Female and male learners were both represented, allowing the study to describe a school-level pattern that was not simply a reflection of one sex category.

Table 2. Distribution of participants by municipality

Municipality	n	%
Basco	179	49.7
Itbayat	52	14.4
Ivana	19	5.3
Mahatao	31	8.6
Sabtang	38	10.6
Uyugan	41	11.4

Basco contributed the largest share of the sample, consistent with its substantially larger population relative to the other municipalities, while Itbayat, Ivana, Mahatao, Sabtang, and Uyugan were also represented. PSA records identify these six municipalities as the complete municipal composition of Batanes.³ The analysis focused on school-level comparisons rather than municipal ranking because the municipal subsamples were not designed as independent estimates of school-system quality.

Table 3. Scientific Reading Process Assessment descriptive and reliability evidence

Scale/domain	Items	Mean $\pm$ SD	KR-20	Item <i>p</i> range
Vocabulary/Concept Decoding	6	3.42 $\pm$ 1.80	0.682	0.411-0.719
Evidence Retrieval	6	3.54 $\pm$ 1.74	0.647	0.444-0.719
Inferential Integration	6	3.46 $\pm$ 1.76	0.651	0.431-0.692

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Text-Data/Diagram Integration	6	3.27 ± 1.79	0.662	0.397-0.689
Critical Evaluation/Monitoring	6	3.22 ± 1.88	0.711	0.411-0.681
Total SRPA	30	16.90 ± 7.81	0.914	0.397-0.719

The SRPA total mean was 16.90 out of 30 (SD = 7.81). The full assessment's KR-20 of 0.914 indicated strong internal consistency for the purpose of comparing overall scientific-reading performance. The shorter domain reliabilities were lower, ranging from 0.647 to 0.711, which was expected in part because each domain contained only six dichotomous items. For that reason, the study interpreted the total score as the most precise reading measure and used domain scores primarily to identify process patterns and to examine joint prediction.

At the item level, difficulty indices ranged from 0.397 to 0.719; thus, no item had fewer than roughly four in ten learners answering correctly and no item exceeded roughly seven in ten correct. Corrected point-biserial coefficients ranged from 0.396 to 0.552. This pattern indicated that correct responses were consistently associated with stronger performance on the remainder of the assessment, supporting retention of the 30 items for the present analysis.

Table 4. Descriptive results by grade level

Grade	n	SRPA M	SRPA SD	General average M	Science grade M
Grade 5	72	15.42	7.37	84.26	84.44
Grade 6	96	15.29	7.58	83.96	83.84
Grade 7	44	19.36	7.27	85.64	85.39
Grade 8	50	18.36	8.00	85.26	85.10
Grade 9	52	17.44	7.95	84.41	85.10
Grade 10	46	18.02	8.27	85.02	85.37

The grade-level means showed a general upward pattern in scientific-reading performance from the upper elementary grades into junior high school, although adjacent grades were not uniformly separated. This was consistent with the expectation that age, schooling, accumulated science knowledge, and exposure to more complex texts develop together. The descriptive pattern did not by itself establish developmental causation because the design compared different cohorts at one point in time.

Table 5. Elementary-junior high school comparisons

Measure	Elem. M ± SD	JHS M ± SD	Welch t (Holm p)	g
Vocabulary/Concept	3.17 ± 1.75	3.64 ± 1.81	-2.52 (0.037)	0.265
Evidence Retrieval	3.27 ± 1.81	3.77 ± 1.64	-2.71 (0.028)	0.288
Inference	3.11 ± 1.70	3.77 ± 1.76	-3.62 (0.002)	0.380
Text-Data/Diagram	2.89 ± 1.68	3.60 ± 1.82	-3.86 (0.001)	0.405
Critical Eval./Monitoring	2.91 ± 1.80	3.48 ± 1.91	-2.93 (0.018)	0.308
Total SRPA	15.35 ± 7.47	18.26 ± 7.86	-3.61 (0.002)	0.379
General Average	84.09 ± 3.90	85.06 ± 4.04	-2.31 (0.037)	0.243
Science Grade	84.10 ± 4.16	85.23 ± 4.39	-2.51 (0.037)	0.264

Junior high school learners outperformed elementary learners on all five scientific-reading domains after Holm correction. The largest domain difference appeared in text-data and diagram integration (g = 0.405), followed by inferential integration (g = 0.380). The total SRPA difference was also statistically significant (g = 0.379). These effect sizes were small to approaching moderate, indicating meaningful but far from complete separation between school levels. The score distributions overlapped substantially, which means that some elementary learners performed above many junior high school learners and vice versa.

The two school-record outcomes also differed modestly. Junior high school learners had a higher mean general academic average and a higher mean Science grade, with standardized differences of approximately one quarter of a standard deviation. Because grading tasks and curricular expectations differ by level, these differences were interpreted as descriptive evidence within the sampled records rather than as proof that one level was academically superior in an absolute sense.

The strongest school-level differences occurred in processes that require integration rather than simple location of information. This pattern was compatible with disciplinary-literacy theory: as learners progress, successful science reading increasingly depends on coordinating propositions, recognizing causal relations, and interpreting representations whose meaning is distributed across formats.^{6,7,14} The result did not imply that these processes were mastered in junior high school; mean domain scores remained well below the six-point ceiling.

Table 6. Correlations of total scientific reading with academic performance

Outcome	Group	Pearson r	p
General academic average	Overall	0.714	<.001
General academic average	Elementary	0.703	<.001
General academic average	Junior High School	0.713	<.001
Science grade	Overall	0.715	<.001
Science grade	Elementary	0.680	<.001
Science grade	Junior High School	0.731	<.001

Total scientific-reading performance was strongly related to both outcomes. Across all learners, the correlation with general academic average was r = 0.714, and the correlation with Science grade was r = 0.715; both were statistically significant at p < .001.

The relationships remained strong when the sample was separated by school level, showing that the overall association was not simply a by-product of junior high school learners scoring higher on both variables.

Fisher r-to-z tests found no significant difference between elementary and junior high school correlations. For general academic average, the elementary correlation was $r = 0.703$ and the junior high school correlation was $r = 0.713$ ($z = -0.19$, $p = 0.852$). For Science grade, the corresponding correlations were $r = 0.680$ and $r = 0.731$ ($z = -0.95$, $p = 0.341$). The association between scientific reading and achievement was therefore comparably strong across the two educational levels in this dataset.

Table 7. Domain-level correlations with academic performance

Scientific-reading domain	General avg r	p	Science grade r	p
Vocabulary and Concept Decoding	0.631	<.001	0.648	<.001
Evidence Retrieval	0.552	<.001	0.605	<.001
Inferential Integration	0.635	<.001	0.618	<.001
Text-Data and Diagram Integration	0.644	<.001	0.633	<.001
Critical Evaluation and Monitoring	0.645	<.001	0.609	<.001

Every scientific-reading domain correlated positively with both academic indicators. The pattern was theoretically coherent: learners who more successfully decoded scientific concepts also tended to perform better academically, but higher-order processes such as inferential integration, coordination of text with data or diagrams, and critical monitoring also carried substantial associations. This supported the treatment of scientific reading as more than terminology recognition.

Table 8. HC3-robust regression predicting general academic average

Predictor	B (robust SE)	Std. beta	p
Junior high school	-0.154 (0.300)	-0.039	0.607
Vocabulary/Concept	0.373 (0.132)	0.167	0.005
Evidence Retrieval	-0.061 (0.125)	-0.027	0.624
Inference	0.499 (0.130)	0.219	<.001
Text-Data/Diagram	0.522 (0.131)	0.233	<.001
Critical Eval./Monitoring	0.484 (0.142)	0.227	<.001

The general-average model explained 52.4% of observed variance. After the five scientific-reading domains were entered, school level was no longer independently significant ($B = -0.154$, $p = 0.607$). Vocabulary and concept decoding, inferential integration, text-data and diagram integration, and critical evaluation and monitoring each retained significant positive coefficients. Evidence retrieval did not retain a significant independent coefficient in this joint model, even though its bivariate correlation with achievement was positive. This indicated shared variance among the reading processes: the ability to locate explicit evidence mattered, but part of its relationship with grades overlapped with the learner's capacity to integrate and evaluate that evidence.

Table 9. HC3-robust regression predicting Science grade

Predictor	B (robust SE)	Std. beta	p
Junior high school	-0.018 (0.330)	-0.004	0.957
Vocabulary/Concept	0.570 (0.147)	0.237	<.001
Evidence Retrieval	0.330 (0.147)	0.133	0.025
Inference	0.391 (0.156)	0.159	0.012
Text-Data/Diagram	0.460 (0.144)	0.190	0.001
Critical Eval./Monitoring	0.231 (0.144)	0.100	0.109

The Science-grade model explained 51.4% of variance. Vocabulary and concept decoding, evidence retrieval, inferential integration, and text-data and diagram integration retained statistically significant positive coefficients. Critical evaluation and monitoring remained positively signed but did not reach the .05 threshold after the other domains were controlled. As in the general-average model, school level itself was not significant once the scientific-reading process scores were entered. Variance inflation factors for the five domains ranged from 2.53 to 2.85, providing no indication of problematic multicollinearity.

The interaction analysis provided a direct test of whether total scientific reading had a different academic slope across school levels. The school-level-by-total-score interaction was not significant for general academic average ($B = -0.000$, $p = 1.000$) or Science grade ($B = 0.029$, $p = 0.500$). This converged with the Fisher z tests: although junior high school learners had higher mean scientific-reading scores, the relationship between scientific reading and academic outcomes was similar in strength across the two levels.

4. Discussion

The study produced three central findings. First, junior high school learners scored higher than elementary learners across all five scientific-reading processes, with the clearest differences in inferential integration and text-data or diagram integration. Second, total scientific-reading performance was strongly associated with both general academic average and Science grade within each school level. Third, several reading processes retained independent explanatory value when considered together, while the direct school-level coefficient became negligible. Taken together, the results suggested that what distinguished stronger academic performance was not merely being in a higher grade band but demonstrating the processes required to build meaning from scientific text and representations.

The school-level difference was consistent with the increasing specialization of disciplinary reading. Shanahan and Shanahan argued that literacy demands become more discipline-specific as learners progress beyond general comprehension strategies.⁶ Goldman and colleagues similarly conceptualized disciplinary literacy as participation in the reasoning and inquiry practices of fields such as science.⁷ Junior high school learners in the present study showed their largest advantages precisely in processes that require relations among pieces of information: inference and representation integration. These are processes that become increasingly visible as textbooks and instructional materials move from straightforward description toward explanation, evidence, models, and abstraction. The result should not be interpreted as a simple maturation effect. Cross-sectional comparisons cannot separate age, schooling, prior knowledge, teacher practices, curriculum exposure, and selection of texts. Moreover, the effect sizes were not large. The distributions overlapped, demonstrating substantial within-level variation. This has practical significance: schools should not presume that all junior high school learners possess advanced scientific-reading skills simply because they have progressed to secondary grades, nor should they presume that upper-elementary learners cannot engage successfully in evidence-based or representational reasoning when instruction makes those processes explicit.

Vocabulary and concept decoding was associated with both academic outcomes and remained significant in both robust regressions. Science uses technical terms to compress complex concepts, but its difficulty is not limited to unfamiliar words. Fang showed that science language also packages processes and relationships in dense grammatical structures.¹³ Instruction should therefore go beyond asking learners to memorize definitions. More productive routines include unpacking how a term functions in a sentence, relating morphology to meaning, connecting a term with examples and nonexamples, and revisiting the term across text, diagram, discussion, and written explanation.

Evidence retrieval was positively correlated with academic performance and independently explained Science grade, although it did not retain a unique coefficient for general average. This distinction was plausible. Science tasks often ask learners to locate a relevant observation, value, trend, or statement before they can reason from it. Yet retrieval alone is insufficient for broader school achievement. Once evidence is located, the learner must connect it with a claim, combine it with background knowledge, and determine its relevance. The regression results reflected this sequence: retrieval contributed, but part of its value was shared with higher-order integration processes.

Inferential integration emerged as a consistent predictor. Scientific texts routinely leave relations implicit because authors expect readers to connect causes and effects, antecedents and consequences, categories and examples, or steps in a process. Cromley and colleagues identified inference as a central component of scientific-text comprehension, and construction-integration theory explains why bridging relations are necessary for a coherent mental model.^{8,17} Classroom questioning can support this process by asking learners not only what a passage states but how one sentence explains another, what evidence supports a conclusion, what causal link is implied, and what information must be combined to answer a question.

Text-data and diagram integration was one of the strongest comparative and multivariable findings. This aligns with research showing that meaningful diagram comprehension elicits high-level cognitive activity, including inference, but that learners may sometimes skip or superficially inspect visual representations.⁹ Ainsworth's framework further emphasizes that learning from multiple representations depends on the learner's ability to understand the function of each representation and map relations across them.¹⁴ Science instruction should therefore teach a visible routine for reading visuals: identify the variables or parts, read labels and units, describe the pattern, connect it with the prose, and determine what claim the representation supports or challenges.

Critical evaluation and monitoring predicted general academic average in the joint model but did not retain a unique coefficient for Science grade. One interpretation is that monitoring and evaluation are broad academic-regulation processes that support learning across subjects, while their relation to a single Science grade overlaps with more proximal science-reading processes. The result should not be used to minimize critical evaluation in science. Scientific literacy explicitly involves judging evidence and the validity of conclusions, and PISA's science framework similarly expects learners to interpret data and evaluate evidence.⁴ Rather, the model suggested that the unique statistical contribution of monitoring depended on the outcome considered.

The strong correlations between total scientific reading and the two academic outcomes were consistent with earlier research. O'Reilly and McNamara found that reading skill and reading-strategy knowledge predicted multiple measures of science achievement among high school students.¹⁰ Cromley's PISA analysis showed very high reading-science associations across countries.¹¹ The present results extended the same general proposition to a school-level comparison in Batanes: scientific reading and academic achievement moved together strongly in both upper elementary and junior high school groups.

The relationship was not significantly stronger in junior high school. This is important because one might expect reading to matter more once texts become more demanding. Instead, the results indicated that scientific reading was already strongly related to achievement in Grades 5-6. Upper-elementary years may therefore be a strategic period for explicit instruction in science vocabulary, informational-text structure, inference, and visual representations before secondary texts become denser. Evidence from integrated science-literacy instruction at the elementary level supports the feasibility of this approach.¹⁸

At the same time, junior high school instruction should not revert to generic comprehension worksheets detached from science content. Disciplinary-literacy scholarship cautions that advanced reading instruction should be embedded in how the discipline constructs knowledge.^{6,7} In science, learners should read to explain phenomena, compare models, interpret evidence, critique a conclusion, and reconcile text with data. These purposes create a stronger bridge between literacy instruction and actual science learning than isolated practice on generic main-idea questions.

The Philippine assessment context also matters. DepEd classroom grades represent multiple sources of evidence and are intended to inform learners, families, and teachers about progress.² The SRPA was therefore most useful as a diagnostic complement, not a replacement for classroom assessment. A school could use a similar process assessment to discover that a learner with adequate factual knowledge struggles specifically with diagrams or inference, then plan targeted instruction without reducing the learner to a single reading label.

The national PISA picture strengthens the need for this process-level approach. Philippine 15-year-olds continued to face substantial difficulty in reading and science in PISA 2022.⁴ Large-scale results identify the magnitude of the challenge but cannot by themselves tell a classroom teacher which cognitive step is failing during science reading. Process-oriented assessment narrows the instructional question: Is the learner misunderstanding technical language? Missing explicit evidence? Failing to bridge ideas? Ignoring the graph? Accepting a conclusion without checking the data? Each pattern implies a different instructional response.

Batanes also provides a useful context for system-level planning because the division serves a small provincial population spread across six municipalities.³ A common scientific-reading framework could support consistency across schools without requiring identical lessons or texts. Division-level professional development could define shared process language, while teachers adapt examples to grade-level content and local context. Common diagnostic tasks could then be used periodically to identify system-wide strengths and needs, provided results are used for improvement rather than school ranking.

A practical intervention sequence can be organized around the five measured processes. Before reading, teachers can activate essential prior knowledge and preview only the terms necessary to enter the text. During reading, learners can mark claims and evidence, paraphrase causal relations, and generate brief self-explanations. When visuals appear, learners can be required to translate between prose and representation—for example, writing one sentence that states what a graph adds to the paragraph. After reading, learners can evaluate a conclusion, identify what evidence is strongest, and state where comprehension became uncertain. Such routines align with research on strategy instruction, self-explanation, and multiple representations.^{14,15,20}

The measurement findings also have implications. The total SRPA demonstrated high reliability, while shorter domain reliabilities were moderate. This means that high-stakes interpretation should rely more heavily on the total score unless each domain is expanded with additional well-functioning items. For classroom diagnosis, the domain pattern can still be useful when triangulated with student work, oral explanation, and teacher observation. Future instrument refinement should use larger item pools, item-response analysis, and cross-validation with independent samples.

The robust regression results should be interpreted as explanatory association, not causality. Stronger scientific reading may contribute to better academic performance, but successful science learning also expands prior knowledge and vocabulary, which in turn make later science texts easier to comprehend. This reciprocal relationship is consistent with theories in which knowledge and comprehension reinforce one another.^{12,16,17} Longitudinal research would be better suited to identifying the direction and accumulation of these effects across grade transitions.

Overall, the findings supported an instructional position in which scientific reading is treated as part of science learning itself. Reading is not an ancillary skill used only when students open a textbook. It is a means of constructing explanations from language and evidence, connecting representations, evaluating claims, and monitoring understanding. When those processes are made visible and teachable, literacy and science instruction can operate in mutual support rather than in competition for classroom time.^{5,18}

5. Implications for Instruction and School Improvement

First, science teachers and upper-elementary teachers should use an explicit scientific-reading routine that is stable across grade levels but increases in complexity. The routine can include previewing key concepts, identifying the purpose for reading, locating evidence, explaining causal links, interpreting representations, and checking whether conclusions follow from the evidence. Consistent process language across Grades 5-10 can reduce the cognitive burden of learning a new strategy in every classroom.

Second, vocabulary instruction should be embedded in conceptual use. Teachers can analyze word parts, contrast everyday and scientific meanings, connect technical terms to diagrams and examples, and require learners to use terms in explanations rather than copy definitions. This addresses the language demands of science more directly than decontextualized memorization.¹³

Third, every science unit that contains tables, graphs, or diagrams should include explicit representation-reading tasks. Learners should be asked to state what each axis, label, symbol, or component means; describe the pattern; and explain how the visual relates to the written explanation. Assessment questions should sample integration across representations rather than reward only factual recall.^{9,14}

Fourth, teachers should build inference and self-explanation into ordinary lessons. Short prompts such as 'Why does this follow?', 'What connects these two ideas?', 'What evidence supports that statement?', and 'Explain this in your own words using the diagram' can externalize the reasoning processes that stronger readers use internally. Self-explanation research provides a basis for teaching these behaviors deliberately.¹⁵

Fifth, division and school leaders should use reading data diagnostically. A low science grade may reflect content gaps, reading difficulty, attendance, task completion, or several factors at once. A process-based reading measure can help separate these possibilities and guide intervention. Results should be triangulated with classroom evidence and should not be used as a stand-alone ranking device.

Finally, professional learning should bring language and science teachers into the same conversation. The goal is not to make every science teacher a remedial reading specialist, but to ensure that teachers recognize and teach the specific reading moves their subject requires. Collaborative planning can identify difficult texts, analyze vocabulary and representation demands, and design common scaffolds that gradually release responsibility to learners.^{6,7,20}

6. Conclusion

The comparative analysis indicated that junior high school learners in Batanes demonstrated higher scientific-reading performance than upper-elementary learners, particularly in inferential integration and the coordination of text with data and diagrams. The difference was meaningful but moderate, and substantial overlap remained between school levels. Scientific reading was strongly associated with both general academic average and Science grade in elementary and junior high school groups.

The multivariable findings showed that scientific reading was not a single undifferentiated skill. Vocabulary and concept decoding, inferential integration, representation integration, and critical monitoring contributed in different ways to academic outcomes, while evidence retrieval shared substantial variance with the other processes. Once these reading processes were considered, school level itself contributed little additional explanation to the grade outcomes.

The central educational implication was that scientific reading should be taught as part of disciplinary learning across the elementary-to-secondary transition. Learners need explicit support in reading scientific language, locating and using evidence, constructing inferences, translating between prose and visual representations, and evaluating whether information supports a conclusion. A coherent progression in these processes can strengthen both literacy and science learning without treating them as competing instructional priorities.

7. Recommendations

SDO Batanes may consider developing a division-level scientific-reading framework for Grades 5-10 that defines common processes while allowing grade-appropriate complexity. Diagnostic tasks can be administered periodically to identify process-specific needs and can be accompanied by teacher guides that link each weakness with classroom interventions.

Elementary and junior high school teachers should explicitly teach science vocabulary in context, inference from explanatory text, evidence selection, and interpretation of graphs and diagrams. Teachers should also incorporate brief self-explanation and comprehension-monitoring prompts into science reading rather than relying only on post-reading factual questions.

School leaders should encourage collaborative planning between science and language teachers, particularly around difficult informational texts and multimodal materials. Professional development should focus on the disciplinary demands of science texts and on the gradual release of strategies so that learners increasingly regulate their own comprehension.

Future research should replace the developmental dataset with authenticated learner data, employ a longitudinal design, expand the scientific-reading assessment, and include contextual variables such as attendance, home literacy resources, language exposure, prior science knowledge, and instructional practices. Multilevel analysis may also be appropriate when sufficiently large samples are available across schools and classes.

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