

Original Article

Navigating Scientific Literacy: A Convergent Parallel Mixed-Methods Analysis of Grade 8 Scholars in Philippine Science High School

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Abstract. Scientific literacy (SL) is increasingly conceptualized as a multidimensional construct that integrates cognitive competence, affective disposition, behavioral engagement, contextual awareness, and technological integration. Within specialized science institutions such as the Philippine Science High School (PSHS) System, scientific literacy is assumed to be inherently strong due to selective admission and rigorous STEM-focused curricula. However, limited empirical investigations have examined how these dimensions interact in high-performing academic environments, particularly during transitional stages of secondary education. This study examined the scientific literacy of Grade 8 students at PSHS–Caraga Region Campus using a convergent parallel mixed-methods design. Quantitative data were collected from 117 students via a standardized PISA 2015 assessment that measured three competencies: identifying scientific issues, explaining phenomena scientifically, and using scientific evidence, as well as a validated multidimensional SL manifestation survey grounded in Kang's framework. Qualitative data were gathered through Focus Group Discussions (FGDs) to explore lived experiences in scientific reasoning, inquiry engagement, and technology use. Results indicated overall Level 3 proficiency, with advanced performance in explaining phenomena (Level 5) and using evidence (Level 4), but a limited ability to identify scientific issues (Level 1b). Although all five SL domains were highly evident, the technological and affective dimensions demonstrated a stronger predictive influence on overall proficiency. Thematic findings revealed patterns of structured reasoning dependence, digital fluency accompanied by evaluative gaps, performance-driven motivation, and emerging inquiry formulation challenges. Convergent integration of quantitative and qualitative findings indicates that conceptual mastery and technological access do not automatically translate into autonomous inquiry competence, particularly in the domain of scientific issue identification. The study advances the Scientific Literacy for Engagement (Sci LiFE) Framework and a Re-Entry Action Plan (REAP) to institutionalize inquiry scaffolding, metacognitive strengthening, and transdisciplinary alignment. The findings contribute to discussions of science education reform in specialized and mainstream secondary contexts.

Keywords: *PISA framework; REAP; Scientific literacy; Sci LiFE Framework; STEM education; Transdisciplinary curriculum*

Scientific literacy has evolved from a narrow focus on factual knowledge acquisition toward a broader competency framework encompassing reasoning, inquiry, evaluation of evidence, and contextual decision-making. Contemporary global assessments define scientific literacy as the capacity to engage with science-related issues reflectively and responsibly, integrating conceptual understanding with procedural and epistemic reasoning (OECD, 2016). In this expanded view, scientific literacy is not merely demonstrated through correct answers but through the ability to formulate investigable questions, evaluate claims critically, and apply knowledge across unfamiliar contexts.

Participation in international large-scale assessments continues to reveal challenges in Filipino students' scientific literacy, particularly in scientific reasoning, inquiry competence, and evidence-based problem solving (Canuto et al., 2024; OECD, 2016). While the Philippine Science High School (PSHS) System was established to cultivate high-performing scholars with strong STEM competencies, institutional performance indicators suggest that academic rigor alone does not guarantee the development of comprehensive scientific literacy. Institutional observations within the Fundamental Years Program, particularly in Grade 8, raise important questions about whether students' conceptual strengths are accompanied by equally strong foundations in inquiry.

Grade 8 represents a pivotal transition from guided foundational instruction toward more abstract disciplinary specialization in biology, chemistry, and physics. During this stage, students are increasingly expected to initiate investigations, justify methodological choices, and transfer scientific reasoning beyond structured classroom tasks. Traditional grading metrics, however, primarily capture content mastery and may not fully reflect multidimensional literacy attributes such as affective resilience, behavioral engagement, contextual application, and technological mediation of learning.

Existing scholarship increasingly conceptualizes scientific literacy as a multidimensional construct that emerges from the interaction among cognitive reasoning, affective engagement, behavioral participation, contextual awareness, and technological competence. Recent studies emphasize that scientific literacy extends beyond content mastery and includes the capacity to formulate scientific questions, evaluate evidence, solve authentic problems, and make informed decisions in science-related contexts. Contemporary inquiry-based and technology-enhanced learning environments have been shown to strengthen scientific literacy by fostering critical thinking, scientific reasoning, and meaningful engagement with real-world issues. These perspectives reinforce the view that scientific literacy develops through the synergistic interaction of cognitive, socio-emotional, contextual, and technological factors operating within science learning environments (Kang, 2022; Alarcon, 2023; Bewersdorff et al., 2025). Despite the conceptual robustness of this model, limited empirical studies have examined its operationalization within specialized science high schools in the Philippines.

Addressing this research gap is institutionally and nationally significant. Understanding how multidimensional scientific literacy manifests among academically selected learners provides insight into whether current pedagogical structures cultivate autonomy in inquiry or reinforce a structured, performance-dependent approach. This study, therefore, investigates the level of scientific literacy, proficiency, and the extent of multidimensional manifestation among Grade 8 students at PSHS–Caraga Region Campus. Beyond measurement, it seeks to generate a data-driven institutional response through the Sci LiFE Framework and its operational Re-Entry Action Plan (REAP).

Methodology

Research Design

The study employed a convergent parallel mixed-methods design to capture both measurable proficiency outcomes and experiential dimensions of scientific literacy. The convergent parallel mixed-methods design allows simultaneous collection and independent analysis of quantitative and qualitative data, followed by integration during interpretation to strengthen corroboration and expansion of findings (Creswell & Creswell, 2018). Quantitative data were gathered through a PISA-aligned scientific literacy assessment, and a multidimensional manifestation survey. In addition, qualitative data were collected through structured Focus Group Discussions (FGDs) with selected Grade 8 scholars. Both strands were implemented concurrently, analyzed independently, and integrated during interpretation. The inclusion of FGDs enabled in-depth exploration of students' reasoning processes, inquiry experiences, technological engagement, and affective responses to science learning. This design enabled corroboration and expansion of findings, allowing qualitative narratives derived from the FGDs to validate, challenge, and deepen the interpretation of quantitative results through methodological triangulation.

Results and Discussion

Scientific Literacy Proficiency Levels

The analysis of PISA-aligned assessment results, as shown in Table 1, indicates that Grade 8 scholars achieved an overall mean score corresponding to Level 3 proficiency ($M = 54.73$). At this level, students demonstrate the ability to apply linked scientific reasoning in familiar contexts, interpret moderately structured data, and draw supported conclusions when guidance is embedded within the task. Level 3 reflects functional literacy but not yet independent or highly abstract scientific reasoning.

Table 1. *Level of Scientific Literacy of the Students per Competency*

Competency	Average Score	Level	Interpretation
Identifying Scientific Issues	25.67	L1b	Demonstrate a little evidence to use content and be able to identify straightforward patterns in simple sources of data.
Explaining Phenomena Scientifically	63.27	L5	Distinguish scientific and non-scientific questions; explain the purposes of enquiry; and control relevant variables.
Using Scientific Evidence	59.89	L4	Draw inferences from different data sources, in a variety of contexts, and explain causal relationships.
Overall Proficiency Level	54.73	L3	Show some evidence of linked scientific thinking and reasoning, usually applied to familiar situations.

Disaggregation by competency reveals a notable performance divergence. Students attained Level 5 proficiency in Explaining Phenomena Scientifically ($M = 63.27$), indicating strong capability to distinguish scientific from non-scientific explanations, identify relevant variables, and articulate causal relationships using appropriate conceptual models. This suggests that scholars are well-equipped to interpret structured scenarios and apply disciplinary knowledge coherently. Similarly, performance in Using Scientific Evidence reached Level 4 ($M = 59.89$), demonstrating competence in interpreting multiple data sources, recognizing patterns, and drawing reasoned inferences. Students were able to analyze data representations and justify conclusions within moderately complex contexts. These findings reflect strong, evidence-based reasoning when the investigation's parameters are clearly defined.

In contrast, Identifying Scientific Issues yielded a mean score corresponding to Level 1b ($M = 25.67$). At this level, students show limited ability to formulate investigable questions independently, recognize underlying scientific variables in unfamiliar contexts, or conceptualize problems requiring systematic inquiry. While they can detect simple patterns in straightforward data, they still find it challenging to initiate inquiry without structured prompts. The disparity between high performance in explanation and evidence interpretation versus low performance in issue identification suggests an asymmetry in inquiry development. Students demonstrate conceptual mastery and reasoning strength once a problem framework is provided; however, generating the problem itself—the foundational step of scientific inquiry—remains underdeveloped. This pattern suggests that current instructional structures may emphasize solution-based reasoning more than question-generation.

The ability to explain abstract phenomena further illustrates this dynamic. Students can competently apply theoretical constructs, such as force, to describe observable outcomes, such as motion. This reflects the internalization of conceptual models and the ability to transfer scientific understanding across contexts. Recent studies indicate that conceptual understanding becomes more meaningful when learners actively engage in scientific inquiry, problem-solving, and evidence-based reasoning. The ability to connect abstract scientific concepts with authentic situations promotes higher-order thinking, strengthens scientific literacy, and supports deeper knowledge transfer across disciplines (Funkhouser & Nicoladis, 2023).

Therefore, while the cohort demonstrates strong explanatory reasoning and evidence usage, strengthening inquiry initiation and problem formulation emerges as a critical curricular priority. Inquiry autonomy develops when learners are immersed in inquiry-based learning environments that require them to formulate scientific questions, identify variables, design investigations, and evaluate evidence independently. Recent studies demonstrate that inquiry-centered instruction significantly improves scientific literacy, critical thinking, and problem-solving skills by engaging students in authentic scientific practices and knowledge construction processes (Alarcon, 2023; Gomez, 2025; Mediana et al., 2025). Enhancing students' ability to identify scientific issues independently may enable progression beyond functional proficiency toward more advanced levels characterized by autonomous inquiry and critical evaluation.

Manifestation of Scientific Literacy Across Domains

Survey results indicate a consistently great extent of manifestation across all five domains of scientific literacy, as shown in Table 2. Mean scores were as follows: Cognitive ($M = 2.97$), Affective ($M = 2.95$), Behavioral ($M = 2.97$), Contextual ($M = 2.96$), and Technological ($M = 2.96$). The relatively low standard deviation values indicate moderate dispersion in responses, suggesting a consistent perception of the manifestation of scientific literacy across respondents. However, closer analytical interpretation reveals qualitative differences in how these domains operate in practice.

Table 2. *Extent of Manifestation of SL in the Five Domains*

Domains	Weighted Mean	SD	Verbal Description
Cognitive	2.97	2.52	High Manifestation
Affective	2.95	2.52	High Manifestation
Behavioral	2.97	2.51	High Manifestation
Contextual	2.96	2.51	High Manifestation
Technological	2.96	2.55	High Manifestation

The Cognitive domain reflects students' perceived ability to apply scientific concepts, interpret data, and reason through structured problems. The high mean indicates confidence in engaging with content knowledge and evidence-based discussions. Nevertheless, when examined alongside proficiency results, this cognitive strength appears more pronounced in guided reasoning than in autonomous analytical elaboration. Students demonstrate competence in applying learned models but engage less frequently in extended evaluative, reflective, and generative thinking processes. Recent reviews of inquiry-based learning research suggest that higher-order cognition is strengthened through authentic problem-solving and opportunities for learners to formulate explanations, evaluate competing claims, and generate solutions to real-world challenges. These experiences promote scientific reasoning and deepen scientific literacy beyond routine content application (Bewersdorff et al., 2025; Mujriati et al., 2025).

The Affective domain likewise manifested to a great extent, indicating positive attitudes toward science, curiosity about scientific developments, and recognition of science's relevance to future careers. Such motivational orientation is critical because affective engagement significantly influences students' persistence, curiosity, and willingness to participate in scientific inquiry. Recent research highlights that positive attitudes toward science contribute to stronger engagement in reasoning activities, greater resilience during problem-solving tasks, and improved scientific literacy outcomes. Students who perceive science as meaningful and relevant are more likely to sustain effort when confronted with complex scientific challenges (Bewersdorff et al., 2025; Gomez, 2025).

Behavioral manifestation reflects active participation in experiments, collaborative tasks, research-related activities, and science communication exercises like engagements in cross-disciplinary activities such as research presentations and community-oriented innovation projects, including initiatives aligned with grassroots innovation programs (Rebuelta, 2024). These behaviors demonstrate the practical application of scientific thinking beyond classroom recitation. However, behavioral engagement does not automatically equate to epistemic depth; participation may remain structured within predefined academic formats rather than open-ended investigative processes.

The Contextual domain indicates students' ability to relate scientific knowledge to real-world issues and societal concerns. High manifestation suggests awareness of science's applicability to environmental, technological, and community contexts. The implementation of learning innovations can significantly boost students' higher-order thinking skills, leading to marked improvements in analytical, creative, and critical thinking. From the learners' perspective, the innovations' content was accessible and effectively bridged the gap between scientific theory and daily life, though some minor gaps in lesson coverage were noted (Kwangmuang et al., 2021). However, contextual awareness must be distinguished from contextual problem formulation; recognizing relevance differs from independently defining investigable community-based issues.

The Technological domain demonstrated strong integration of digital tools in learning processes. Students reported frequent use of online resources, simulations, collaborative platforms, and AI-assisted searches to clarify scientific concepts. This digital fluency enhances access to information and supports conceptual reinforcement. Nevertheless, integration of technology does not inherently ensure critical evaluation of digital sources. Qualitative narratives indicate that while students are efficient in locating information, systematic credibility

assessment and epistemic scrutiny vary in consistency.

Overall, the high prevalence across domains suggests that students have a supportive ecosystem for developing scientific literacy. However, when interpreted alongside proficiency findings, the results reveal that multidimensional engagement is strongest in structured, guided environments. Strengthening independent inquiry formulation and epistemic evaluation may allow these manifested domains to translate more fully into advanced scientific literacy proficiency.

Correlation and Principal Component Analysis

Spearman's rho correlation analysis, shown in Table 3, revealed statistically significant, very strong positive associations between overall scientific literacy proficiency and each of the five domains ($\rho = .887-.971, p < .001$). These results indicate that scientific literacy is not solely a cognitive outcome but is strongly intertwined with affective engagement, behavioral participation, contextual awareness, and technological integration.

Table 3. *Spearman ρ Correlation of the Five (5) Domains*

Dimension	Spearman ρ	Strength	Significance
Cognitive	0.887	Strong	$p < 0.001$
Affective	0.966	Very Strong	$p < 0.001$
Behavioral	0.968	Very Strong	$p < 0.001$
Contextual	0.934	Very Strong	$p < 0.001$
Technological	0.971	Very Strong	$p < 0.001$

The strongest correlations were observed in the Technological ($\rho = .971$), Behavioral ($\rho = .968$), and Affective ($\rho = .966$) domains, suggesting that students who demonstrate proactive engagement, positive scientific disposition, and effective use of digital tools tend to achieve higher proficiency levels. These findings align with Canuto et al. (2024), who emphasized that instructional quality and engagement-oriented teaching practices significantly shape students' scientific literacy development. Recent studies suggest that scientific literacy outcomes emerge through the interaction of cognitive, affective, behavioral, and technological dimensions that collectively shape students' engagement and decision-making capacities (Bewersdorff et al., 2025; Mujriati et al., 2025).

Principal Component Analysis (PCA), as shown in Table 4, a widely used technique for reducing dimensionality and identifying latent structures among correlated variables (Jolliffe & Cadima, 2016), further confirmed the structural cohesion of the five scientific literacy domains. The first principal component (PC1) accounted for 93.3% of the total variance, and PC1 and PC2 together accounted for 96.3%. Although PC2 was extracted during PCA and contributed an additional 3.0% of variance, only PC1 was retained for regression analysis because it had the greatest explanatory power and its eigenvalue exceeded the standard retention threshold. The high explained variance indicates substantial shared covariance among the domains, reinforcing the interpretation that scientific literacy functions as a unified yet multidimensional construct.

Table 4. *Principal Component 1 Analyses of the Five Dimensions of SL*

Dimension	PC1 Loading	PC2 Loading	Explained Variance (PC1)	Explained Variance (PC2)	Cumulative Variance (PC1+PC2)
Cognitive	-0.435	0.867	0.933	0.030	0.963
Affective	-0.450	-0.134	0.933	0.030	0.963
Behavioral	-0.449	-0.384	0.933	0.030	0.963
Contextual	-0.451	-0.036	0.933	0.030	0.963
Technological	-0.451	-0.285	0.933	0.030	0.963

Although PC1 yielded a negative coefficient in the regression output, this reflects a statistical rather than a substantive negative influence. All five domains demonstrated strong positive loadings on PC1, indicating that each dimension contributes substantially to the shared variance captured by the principal component. The uniformly high loadings further confirm the structural cohesion of scientific literacy as a multidimensional yet unified construct.

Taken together, the correlation and PCA results substantiate the multidimensional theoretical framing of scientific literacy. The findings demonstrate that proficiency is strengthened not only by conceptual understanding but also by affective commitment, behavioral engagement, contextual relevance, and technological competence. These are dimensions that collectively support the development of scientifically literate learners in specialized academic

settings.

At the practice level, the findings encourage teachers to transition from performance-oriented tasks toward inquiry-centered learning experiences. At the policy level, they support curriculum recalibration to ensure that inquiry autonomy develops in proportion to the rigor of the content. At the research level, the study demonstrates the value of integrating mixed-methods to capture multidimensional literacy patterns and recommends longitudinal investigation across grade levels to examine developmental trajectories.

Sci Life Framework

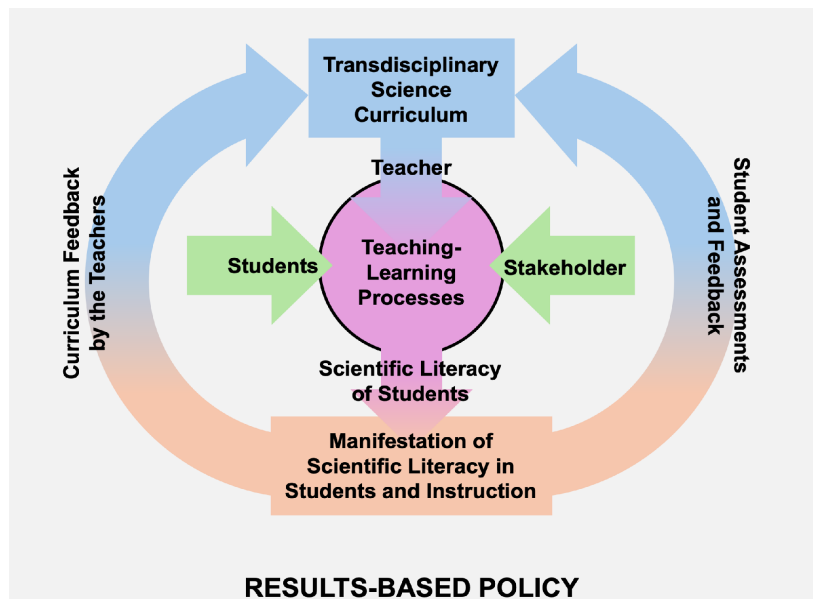


Figure 1. *Results-Based Policy Framework for Scientific Literacy Development*

The strategic planning process for improving students' scientific literacy (SL) involves understanding both internal and external environments, setting clear objectives, creating actionable plans, and ensuring continuous evaluation. Based on the study's findings, the PSHSS WAY FORWARD Framework provides a comprehensive approach for developing students, faculty, and administration. This framework focuses on enhancing student competitiveness, creating world-class outputs, providing future-proof education, establishing a recognizable brand for STEM education, and deepening socio-emotional skills. The proposed framework in figure 1 centers on the learners and curriculum.

The Scientific Literacy for Engagement (Sci LiFE) Framework is proposed as a results-based institutional response grounded directly in the empirical findings of this study. Rather than serving as a generic strategic model, the framework specifically addresses the asymmetry identified in the results—namely, strong explanatory and evidence-based reasoning alongside limited inquiry formulation skills. It also capitalizes on the high manifestation across affective, behavioral, contextual, and technological domains.

As illustrated in Figure 1, the framework positions the Teaching-Learning Process at the core, dynamically influenced by interactions among students, teachers, and stakeholders. Surrounding this core is a Transdisciplinary Science Curriculum, designed to integrate scientific reasoning across subject boundaries intentionally. This transdisciplinary orientation moves beyond simple content alignment; it systematically scaffolds inquiry initiation, variable recognition, hypothesis construction, and authentic problem identification—competencies identified as developmental gaps in the proficiency analysis.

The Sci LiFE Framework operates through a cyclical improvement structure. Student assessment and curriculum feedback mechanisms function as continuous diagnostic inputs that inform instructional refinement. Assessment is reconceptualized not as a terminal performance indicator but as formative evidence guiding the strengthening of inquiry competence and multidimensional literacy engagement.

Grounded in the correlation and PCA findings, the framework operationalizes the cohesive multidimensional structure of scientific literacy. Cognitive reasoning, affective commitment, behavioral participation, contextual awareness, and technological fluency are cultivated in parallel rather than sequentially. Teachers are positioned as facilitators of progressively released inquiry, guiding students from structured tasks toward increasingly autonomous and open-ended investigations. Stakeholder collaboration, including research mentors, community partners, and industry linkages, enhances contextual authenticity and reinforces real-world application of scientific knowledge.

Continuous monitoring of proficiency levels, domain manifestation patterns, and qualitative insights ensures responsive curriculum recalibration. This cyclical model prevents static policy implementation and instead promotes adaptive institutional growth. Through this integrated engine, the Sci LiFE Framework transforms empirical evidence into actionable educational strategy, advancing the development of inquiry-driven, critically engaged, and technologically competent learners within specialized science high school settings. In doing so, the framework operationalizes the OECD (2016) conception of scientific literacy by explicitly embedding epistemic reasoning, inquiry autonomy, and contextual problem formulation within transdisciplinary instruction.

Qualitative Insights and Mixed-Methods Integration

The qualitative findings provided critical explanatory depth to the quantitative patterns observed in this study. Thematic analysis of the Focus Group Discussions generated three dominant themes: (1) applied conceptual confidence, (2) technology-facilitated learning engagement, and (3) inquiry initiation difficulty. These themes collectively illuminate how students experience and operationalize scientific literacy within the PSHS–CRC learning environment.

Students consistently expressed confidence in explaining scientific concepts and applying them to familiar contexts, reflecting strong cognitive integration and alignment with their Level 3 proficiency classification. Many participants described science learning as accessible and engaging, particularly through digital tools and online platforms. This reinforces the high manifestation scores observed in the technological and affective domains and suggests that digital engagement, when supported by structured instructional scaffolds, enhances students' participation in scientific reasoning processes.

Despite this applied confidence, several students reported difficulty in initiating scientific questioning and independently formulating investigative problems. This qualitative hesitation corresponds directly with the lower quantitative performance in the "Identifying Scientific Issues" competency. While students demonstrated strength in explaining phenomena and interpreting evidence, the foundational epistemic skill of problem formulation remained comparatively underdeveloped. This pattern aligns with contemporary science education literature, which emphasizes that inquiry initiation requires explicit instructional scaffolding, guided questioning strategies, and structured opportunities for independent investigation. Recent evidence suggests that students develop stronger inquiry competencies when teachers progressively release responsibility for question generation, investigation design, and evidence evaluation, thereby promoting autonomous scientific reasoning and deeper scientific literacy development (Alarcon, 2023; Mediana et al., 2025; Kang, 2022).

The convergence between statistical results and narrative accounts strengthens the interpretive validity of the study. Quantitative analyses revealed strong multidimensional cohesion among cognitive, affective, behavioral, contextual, and technological domains, as evidenced by very strong correlation coefficients and high variance concentration in the first principal component. Qualitative themes corroborated this structural integration while simultaneously revealing asymmetry within inquiry-based competencies. This methodological triangulation confirms that scientific literacy among PSHS–CRC students is robust yet unevenly distributed across its epistemic components.

The integration of both strands substantiates the multidimensional conception of scientific literacy articulated by OECD (2016). It affirms that proficiency development must extend beyond content mastery toward inquiry autonomy and contextual problem formulation. The mixed-methods design, therefore, not only validated statistical relationships but also clarified the experiential mechanisms underlying them, providing an empirically grounded basis for developing the Sci LiFE Framework.

Conclusion

This study employed a convergent parallel mixed-methods design to examine the multidimensional structure of scientific literacy among Grade 8 scholars in a specialized science high school. Integrated findings indicate overall Level 3 proficiency, characterized by advanced explanatory and evidentiary reasoning alongside constrained inquiry initiation and scientific issue identification. This developmental asymmetry suggests that while conceptual mastery is strong, autonomous problem formulation remains underdeveloped.

Although manifestation across cognitive, affective, behavioral, contextual, and technological domains was consistently high, these strengths were most evident in structured, guided learning environments. The results suggest that conceptual mastery, digital fluency, and motivational engagement do not automatically translate into autonomous inquiry competence. Scientific literacy in this cohort is multidimensional and statistically cohesive, yet uneven in its developmental expression.

Correlation and principal component analyses confirmed that literacy outcomes are shaped through the integrated interaction of cognitive reasoning, affective commitment, behavioral engagement, contextual awareness, and technological competence. No single domain independently drives proficiency; rather, literacy emerges from their collective reinforcement.

Grounded in these findings, the Scientific Literacy for Engagement (Sci LiFE) Framework is proposed as a results-based institutional strategy. By embedding transdisciplinary integration, cyclical assessment feedback, and progressive inquiry scaffolding into the teaching-learning process, the framework addresses the identified gap in problem formulation while sustaining strengths in explanation and evidence-based reasoning.

While the findings provide robust insight into scientific literacy within a specialized science high school, the study is limited to a single institutional context and a cross-sectional cohort, which may constrain generalizability across other PSHS campuses or mainstream public schools.

The study contributes to the growing body of literature emphasizing that scientific literacy development in high-performing STEM contexts requires intentional cultivation of inquiry autonomy alongside content rigor. By situating scientific literacy within a multidimensional, statistically cohesive framework, the study extends current discussions of literacy development in high-performing STEM institutions. The findings provide empirical guidance for curriculum refinement, teacher professional development, and policy planning within specialized and mainstream secondary education systems.

Contributions of Authors

Jhon Ryan P. Hijastro: conceptualization, data collection, instrument development, data analysis, manuscript writing, and content revision.

Prof. Faith P. Villanueva: supervised the review and critique of content, provided academic advising throughout the research process, and evaluated the final manuscript.

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Conflict of Interests

The author declares **no conflict of interest** related to the conduct and publication of this research study.

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