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Assessment of Scientific Literacy Skills Among Preservice Teachers

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Abstract
Scientific literacy is an essential competency for preservice teachers (PSTs), and preservice teacher education represents a critical leverage point for strengthening scientific literacy in future science classrooms. This study assessed the scientific literacy skills of PSTs and examined its curricular integration using a mixed-methods design that combined the Test of Scientific Literacy Skills (TOSLS), focus group discussions (FGDs), and syllabi analysis. Quantitative findings from 120 PSTs revealed an overall Functional level of scientific literacy (M = 12.13, SD = 2.76), with scores increasing from first-year (M = 11.19) to fourth-year students (M = 12.87). Despite this progression, PSTs consistently struggled with skills related to evaluating source validity, interpreting statistical data, constructing graphical representations, and understanding research design – skills vital to scientific reasoning. High variability in scores further indicated uneven skill development across cohorts. Qualitative data echoed these challenges, with faculty and PSTs citing barriers such as limited inquiry-based learning, inadequate laboratory access, and predominance of lecture-based instruction. Syllabi analysis also showed partial alignment with scientific literacy goals; however, the concept remained implicit and was not systematically assessed, with evaluation methods largely reliant on traditional testing formats. These findings highlight the fragmented development of scientific literacy among PSTs and emphasize the urgent need for explicit curricular integration, inquiry-based pedagogy, and enhanced instructional resources. Addressing these gaps is crucial to preparing future science educators who are both scientifically literate and pedagogically equipped.

Keywords: science curriculum, preservice teachers, science education, scientific literacy, teacher education

1. Introduction

Integrating science education courses into the curriculum is essential for cultivating the skills and values embedded in national educational goals. A central aim of science education is to prepare students to engage thoughtfully with scientific issues and make informed decisions on socio-scientific matters (Holbrook & Rannikmae, 2007;2009). This objective aligns with the broader goal of fostering scientific literacy, defined as the ability to engage with science-related issues and ideas as a reflective citizen, including explaining scientific phenomena, evaluating and designing scientific inquiry, and interpreting data and evidence scientifically (OECD, 2019).

In contemporary science education, scientific literacy is not merely the acquisition of scientific knowledge, but a set of competencies that enable individuals to reason with evidence and apply scientific understanding in real-world contexts. Gormally et al. (2012) operationalized scientific literacy as a set of measurable skills related to recognizing and analyzing the use of methods of inquiry, and to organizing, analyzing, and interpreting quantitative data and scientific information.

In the Philippines, the science curriculum aspires to produce scientifically literate citizens who understand their environment and contribute meaningfully to society (Montebon, 2014). Filipino science students are expected to participate in civic discourse, make reasoned decisions, and apply scientific knowledge to everyday challenges. However, the country's average score of 357 in the scientific literacy component of the 2018 Programme for International Student Assessment (PISA), the lowest among ASEAN member countries, signals a pressing need to improve science education outcomes (Department of Education, 2019; OECD, 2019).

Teachers play a pivotal role in advancing scientific literacy, as their ability to engage in scientific reasoning and evaluate evidence directly influences classroom practice. While extensive research has examined students' scientific literacy, studies in the Philippines also indicate that preservice teachers (PSTs) themselves experience difficulties in core scientific literacy skills (Flores, 2019; Gutierrez et al., 2018; Walag et al., 2022). International studies further suggests that preservice teachers often exhibit limited proficiency in key scientific literacy, such as scientific inquiry, quantitative and statistical literacy, and real-world application of science concepts (Al Sultan et al., 2018; Cavas et al., 2013; Fakhriyah et al., 2017).

Consistent with these findings, the literature has shown that preservice teachers demonstrate varying levels of scientific literacy, with persistent weakness in areas such as nature of science, scientific inquiry, and the interpretation of quantitative data (Chin, 2011; Sarini et al, 2024). These concerns emphasize the importance of examining scientific literacy within the teacher education context, particularly during the pre-service training.

Given the importance of scientific literacy in preservice teacher education and the limited research examining its context in the Philippines, this study aims to assess the scientific literacy skills of preservice teachers' (PSTs'). Specifically, the study focuses on skills related to: (1) recognizing and analyzing methods of scientific inquiry, and (2) organizing, interpreting, and evaluating quantitative data and scientific information, as well as examining PSTs learning experiences within teacher education programs.

By focusing on PSTs, this study identifies a strategic leverage point for improving science education nationwide. As future educators, PSTs play a pivotal role in shaping students' understanding of science. If they lack adequate scientific literacy skills, they may struggle to teach science effectively - potentially perpetuating the cycle of low student performance reflected in the Philippines' PISA results. Assessing their scientific literacy skills offers insights that may inform instructional design and support efforts to strengthen preservice teacher education preparation.

2. Literature Review

This review examines scientific literacy as a central goal of science education, its status within the Philippine educational context, and empirical evidence on the scientific literacy of preservice teachers (PSTs). Collectively, the literature highlights persistent gaps in higher education research, particularly in understanding and strengthening scientific literacy among future science educators.

2.1 Scientific Literacy and Its Importance

Scientific literacy is a cornerstone of effective science instruction, especially for preservice teachers (PSTs) who are preparing to become science educators. It encompasses not only a robust understanding of scientific concepts but also the ability to think critically, apply scientific reasoning, and make informed decisions about complex, real-world issues (OECD, 2022). The development of scientific literacy in PSTs is essential for fostering classroom environments that encourage inquiry, evidence-based reasoning, and a positive disposition towards science (Riegle-Crumb et al., 2015; Talavera-Mendoza et al., 2024). Scientifically literate teachers are better equipped to implement inquiry-based pedagogies that actively engage students and promote the development of their own scientific literacy. Adequate training for PSTs enables them to guide learners through processes of exploration, experimentation, and reflection, which are the core practices that nurture critical thinking and informed decision-making (Mulyono et al., 2024).

2.2 Scientific Literacy in the Philippine Context

The Philippines continues to face significant challenges in realizing its curricular goal of cultivating scientifically literate citizens. Although the national science curriculum emphasizes the development of scientific literacy (Montebon, 2014), international assessments such as the Programme for International Student Assessment (PISA) reveal persistently low proficiency levels among Filipino students (DepEd, 2019; OECD, 2019). These outcomes point to systemic issues in science education that must be addressed across multiple levels, particularly in the preparation of future educators.

While most of the existing research in the Philippines has focused on students' scientific literacy at the basic education level (Bernardo et al., 2023; Cordon & Polong, 2020; Palines & Ortega-Dela Cruz, 2021), studies examining scientific literacy within higher education, particularly in teacher education programs, remain limited (Flores, 2019; Gutierrez et al., 2018). This gap is significant, given that preservice teachers play a central role in shaping how scientific literacy is enacted in future classrooms.

The studies in the Philippines about PSTs' scientific literacy reveal a mixed level of scientific literacy. Flores (2019) reported that preservice secondary science teachers exhibited satisfactory levels of scientific literacy but only moderate teaching self-efficacy. This indicates potential challenges in translating scientific knowledge into instructional practice. Similarly, Gutierrez et al. (2018) found minimal improvement over time in PSTs' scientific literacy skills, particularly in evaluating science arguments, interpreting quantitative data, and justifying conclusions. More recent work by Lu-ong (2023) assessed undergraduate Biology students' scientific literacy using the Test of Scientific Literacy Skills (TOSLS). Students demonstrated moderate to high proficiency in basic skills; however, they struggled with higher-order competencies such as evaluating arguments and interpreting quantitative data.

2.3 Evidence from International Studies

International research further corroborates concerns regarding PSTs' scientific literacy. Chin (2011), in a study of first-year preservice teachers in Taiwan, found generally satisfactory levels of basic scientific literacy; however, significant weaknesses were observed in areas such as the nature of science and earth science. The study also revealed differences in scientific literacy across program specialization and prior science experiences, which highlights variability in PST preparedness.

Further evidence from Southeast Asian contexts reinforces concerns regarding the scientific literacy of preservice teachers. Fakhriyah et al. (2017) reported that the scientific literacy skills of prospective science teachers in Indonesia were low and not significantly different from students' scientific literacy levels as reported in the Programme for International Student Assessment. Similarly, other studies have found that prospective science teachers' scientific literacy remains low across multiple domains (Pahrudin et al., 2019; Sartika et al., 2018). Sunarti (2015) further observed that prospective science teachers were generally able to answer scientific literacy items only at low cognitive levels, which suggests limited capacity for higher-order scientific reasoning and evidence-based evaluation.

Moreover, a recent study using skills-based assessments has reported lower levels of scientific literacy among PSTs. Sarini et al. (2024) employed the TOSLS in an Indonesian context and found very low proficiency in bot major scientific literacy domains: evaluating scientific inquiry methods and interpreting quantitative data and science information. These results suggest that PSTs struggle with core scientific reasoning skills essential for effective science education.

Additional international studies have demonstrated strong associations between PSTs' scientific literacy and their confidence and efficacy in teaching science (Al Sultan et al., 2018). Teacher education programs that integrate disciplinary literacy frameworks and inquiry-oriented approaches have shown promise in enhancing PSTs' instructional capacity (Gao et al., 2022). Without a solid foundation in scientific literacy, PSTs may encounter difficulties designing learning experiences that promote critical thinking, evidence evaluation, and scientific reasoning among students.

Taken together, the literature indicates that while scientific literacy is a central goal of science education, significant challenges persist in its development among preservice teachers. In the Philippine context, empirical studies remain scarce and suggest uneven proficiency in key scientific literacy skills. International evidence further highlights persistent weaknesses in scientific inquiry, data interpretation, and the nature of science among PSTs.

3. Methodology

3.1 Research Design

This study employed a mixed-methods research design that integrated both quantitative and qualitative approaches to provide a comprehensive understanding of scientific literacy among preservice teachers (PSTs) in a higher education institution in the Philippines. The quantitative component established baseline scientific literacy levels, while the qualitative component provided contextual explanations of PSTs' learning experiences and examined curricular support for scientific literacy. Triangulation was applied to enhance the validity and depth of findings by combining multiple data sources - quantitative, qualitative, and documentary – to ensure a more holistic description of PSTs' scientific literacy (Creswell & Plano Clark, 2018).

3.2 Research Participants

The quantitative phase involved 120 preservice teachers enrolled across first- to fourth-year levels in the Bachelor of Secondary Education major in Science program. Census sampling was employed to ensure full representation of the target population.

For the qualitative phase, purposive sampling was used to select participants for the focus group discussions (FGDs). One FGD consisted of preservice teachers who had completed core science education courses and were willing to share their learning experiences related to scientific literacy development. A second FGD involved five science faculty members directly engaged in teaching science education courses, selected based on their instructional roles and familiarity with the program curriculum. This sampling approach ensured that participants could provide relevant and information-rich perspectives aligned with the study objectives.

3.3 Research Instruments

The primary instrument for the quantitative phase was an adapted version of the Test of Scientific Literacy Skills (TOSLS) (Appendix A) developed by Gormally et al. (2012). The instrument measures scientific literacy as a set of skills related to (1) recognizing and analyzing methods of scientific inquiry and (2) organizing, interpreting, and evaluating quantitative data and scientific information. The adapted tool was pilot tested with 102 PSTs, yielding a Cronbach's alpha of 0.708, indicating acceptable internal reliability. Content validity was established through expert review by three specialists in science education and assessment.

For the qualitative phase, semi-structured FGD guides (Appendix B) were developed to explore PSTs' experiences and perceptions regarding the development of their scientific literacy, alongside faculty perspectives on curricular support. These guides were also validated by the same panel of experts to ensure clarity, relevance, and alignment with the study objectives.

In addition, official copies of science course syllabi implemented during the semester of the study were collected upon approval from the department head. These documents were analyzed to determine how course objectives, content, and activities supported scientific literacy development.

3.4 Data Collection

Data collection was conducted in three phases. The scientific literacy assessment was first administered to all participating preservice teachers during scheduled class sessions, following standardized procedures to ensure consistency. This was followed by focus group discussions with selected preservice teachers and science faculty members, which were conducted either face-to-face or online, depending on participant availability. All focus group sessions were audio-recorded with participant consent and transcribed verbatim for analysis. Finally, official copies of science course syllabi were collected from the department and reviewed to examine how curricular components supported the development of scientific literacy competencies.

3.5 Data Analysis

Quantitative data from the scientific literacy assessment were analyzed using descriptive statistics, including mean scores and standard deviations, to determine PSTs' proficiency across scientific literacy skill domains. Raw scores were interpreted using predefined criteria adapted from Uno and Bybee's (1994) scientific literacy framework, which categorizes performance into four levels: Nominal, Functional, Conceptual, and Multidimensional. The score ranges and corresponding literacy levels used in this study are presented in Table 1. In addition, skill-level performance was interpreted using percentage-based descriptors, where scores of 0–39% were classified as Very Low, 40–59% as Low, 60–79% as Moderate, and 80–100% as High. These classifications guided the interpretation of both overall and domain-specific results reported in the Findings section.

Table 1: Interpretation of Scientific Literacy Scores Based on the Uno and Bybee (1994) Framework

Scientific Literacy Level	Score Range	Percentage
Nominal	0-7	0-24%
Functional	8-15	25-49%
Conceptual	16-23	50-74%
Multidimensional	24-30	75-100%

Qualitative data from the FGDs were analyzed using thematic analysis following Braun and Clarke's (2006) six-phase approach: familiarization with the data, initial coding, theme development, theme review, theme definition, and reporting. This process enabled the identification of patterns related to PSTs' learning experiences and perceived factors influencing scientific literacy development.

Document analysis of course syllabi were conducted using directed content analysis (Hsieh & Shannon, 2005). Syllabi were examined for alignment between course objectives, instructional strategies, and assessment practices and established dimensions of scientific literacy, as described in skills-based frameworks (Gormally et al., 2012; OECD, 2022). Findings from the qualitative and document analyses were used to contextualize and explain patterns observed in the quantitative results, ensuring consistency between data analysis procedures and reported findings.

3.6 Ethical Consideration

Ethical clearance was obtained from the Research Ethics Committee of MSU–IIT and the Chancellor of the participating institution. Informed consent was secured from all participants prior to data collection. Participants were assured of confidentiality, anonymity, and their right to withdraw from the study at any time without penalty.

4. Results

This section presents the integrated results of the study, drawing from both quantitative and qualitative data to provide a comprehensive understanding of scientific literacy among preservice science teachers (PSTs). The findings are organized into three key areas: (1) the current proficiency levels of PSTs based on standardized assessment data, (2) PSTs' perceptions and experiences regarding the development of scientific literacy throughout their teacher education program, and (3) the extent to which science course syllabi align with the goals and dimensions of scientific literacy. Together, these findings offer a nuanced view of how scientific literacy is cultivated, challenged, and supported within the institutional context.

4.1 PSTs' Proficiency in Scientific Literacy

This section presents the quantitative findings on the scientific literacy levels of preservice teachers (PSTs), as measured by the Test of Scientific Literacy Skills (TOSLS). As shown in Table 2, PSTs across all year levels demonstrated a Functional level of scientific literacy, based on Uno and Bybee's (1994) classification framework. The overall mean score was 12.13 (SD = 2.76), indicating that PSTs possess the ability to comprehend and utilize basic scientific information. However, this level also suggests limitations in applying scientific concepts to complex or unfamiliar situations—an essential competency for effective science instruction. These results provide a foundational understanding of PSTs' current proficiency and highlight areas requiring targeted pedagogical support.

Table 2: Relevance of objectives of teaching subjects at the university

Year Level	*N*	Mean Score	Std. Deviation	Scientific Literacy Level
1st Year	27	11.19	2.66	Functional
2nd Year	38	11.97	2.68	Functional
3rd Year	32	12.59	2.18	Functional
4th Year	23	12.87	3.47	Functional
Total	120	12.13	2.76	Functional

A closer analysis of year-level data revealed a gradual increase in mean scores, from first-year students (M = 11.19) to fourth-year students (M = 12.87), suggesting incremental improvement in scientific literacy as PSTs advance through their teacher education program. However, despite this upward trend, all cohorts remained within the Functional category of Uno and Bybee's (1994) scientific literacy framework. This indicates that while PSTs may be gaining familiarity with basic scientific concepts and reasoning, they have yet to demonstrate proficiency in applying these skills to more complex or unfamiliar contexts - a hallmark of higher literacy levels.

To further unpack these results, item-level analysis of the Test of Scientific Literacy Skills (TOSLS) was conducted. This revealed specific competencies where PSTs consistently underperformed, pointing to critical areas that require targeted instructional intervention. Table 3 presents these competencies, highlighting persistent challenges in evaluating source credibility, interpreting statistical data, constructing graphical representations, and understanding research design.

Table 3: Performance of Preservice Teachers on Specific Scientific Literacy Skills

TOSLS Skill	Mean	SD	% of Max	Interpretation
I. Understand methods of inquiry that lead to scientific knowledge				
1. Identify a valid scientific argument	1.75	1.09	35%	Very Low
2. Evaluating the validity of sources	1.32	0.85	33%	Very Low
3. Evaluate the use and misuse of scientific information	1.96	0.75	65%	Moderate
4. Understand elements of research design and how they impact scientific findings/conclusions	1.12	0.79	37%	Very Low
II. Organize, analyze, and interpret quantitative data and scientific information				
5. Create graphical representations of data	0.64	0.61	32%	Very low
6. Read and interpret graphical representations of data	1.51	0.87	38%	Very Low
7. Solve problems using quantitative skills, including probability and statistics	1.42	0.83	47%	Low
8. Understand and interpret basic statistics	0.66	0.65	33%	Very low
9. Justify inferences, predictions, and conclusions based on quantitative data	1.77	1.03	44%	Low

Preservice teachers (PSTs) demonstrated moderate performance in evaluating the use or misuse of scientific information (M = 1.96, SD = 0.75), suggesting a relatively high capacity to detect misinformation and assess the integrity of scientific claims. However, the elevated standard deviation within this domain indicates considerable variability while some PSTs excelled, others struggled to apply these evaluative skills consistently.

In contrast, markedly very low mean scores were observed in several core competencies: evaluating the validity of sources (M = 1.32, SD = 0.85), understanding basic statistics (M = 0.66, SD = 0.65), creating graphical representations (M = 0.64, SD = 0.61), and understanding the impact of research design (M = 1.12, SD = 0.79). These results point to significant gaps in source evaluation, statistical literacy, and comprehension of methodological rigor - skills essential for interpreting scientific information and guiding inquiry-based learning.

Low proficiency was recorded in solving statistical problems (M = 1.42, SD =0.83) and justifying inferences from data (M = 1.77, SD = 1.03), indicating partial development of analytical reasoning. Nonetheless, the consistently high standard deviations across most skill areas reflect uneven acquisition, with some PSTs demonstrating emerging competencies while many still lack foundational understanding. Overall, the data reveal substantial variation in scientific literacy skills, underscoring the need for differentiated instructional support and targeted curriculum interventions.

As presented in Table 4, PSTs showed an overall low proficiency in the domain of *Understanding methods of inquiry that lead to scientific knowledge* (M = 6.14, SD = 1.82), which suggests a foundational awareness of scientific processes and investigative approaches. However, their performance in *Organizing, analyzing, and interpreting quantitative data and scientific information* was comparatively weaker (M = 5.99, SD = 1.99), which highlights persistent challenges in handling empirical evidence and engaging with data-driven reasoning. These domain-level findings reinforce the need to strengthen PSTs' competencies in both conceptual and procedural aspects of scientific literacy.

Table 4: Level of Scientific Literacy of PSTs in Two TOSLS Categories

Category	Mean	SD	% Maximum	QI
I. Understanding methods of inquiry that lead to scientific knowledge	6.14	1.82	40.9%	Low
II. Organizing, analyzing, and interpreting quantitative data and scientific information	5.99	1.99	39.9%	Low

4.2 PSTs' and Science Teachers' Perceptions of Scientific Literacy

This section explores the perceptions of preservice teachers (PSTs) and science faculty regarding the development of scientific literacy within the classroom context. Drawing from qualitative data gathered through focus group discussions, several key themes emerged that illuminate participants' understanding of scientific literacy, their lived experiences in science education, and the challenges they encounter in fostering this competency. These themes provide critical insight into how scientific literacy is conceptualized and operationalized in teacher education, revealing both strengths and systemic barriers that shape instructional practice.

4.2.1 Systemic and Instructional Barriers

Analysis of focus group discussions (FGDs) and interviews revealed a range of systemic and instructional barriers that hinder the development of scientific literacy (SL) among preservice teachers (PSTs) and faculty members. Three major subthemes emerged from the data: limited resources and facilities, pedagogical challenges, and structural and curricular constraints.

Both PSTs and faculty consistently emphasized the lack of adequate laboratory spaces, instructional tools, and updated materials as significant impediments to effective science teaching and learning. These resource gaps restrict opportunities for hands-on, inquiry-based activities which are key components in fostering scientific literacy. As one PST shared, *"No resources for experiments... my understanding and learning experience remain limited."* A faculty member echoed this concern, stating, *"There is limited access to labs or updated materials."* The absence of experiential learning environments was seen as a major obstacle to cultivating critical thinking and scientific reasoning.

Participants also identified instructional approaches as a recurring concern. PSTs noted that teaching strategies were predominantly lecture-based, with minimal effort to accommodate diverse learning styles or promote active engagement. One PST remarked, *"Concepts need demonstration, but we're limited to pure lectures... teachers don't try alternative approaches."* Another added, *"Teaching strategies don't align with my learning style at all, which is more of learning by doing."* Faculty members acknowledged this gap and highlighted the need for professional development focused on designing activities that foster higher-order thinking and scientific literacy. As one faculty participant stated, *"Faculty need workshops on designing activities for developing higher-order thinking and scientific literacy."* Others pointed to the absence of structured pedagogical frameworks, noting, *"There's no clear guide on how to develop scientific literacy... It's not written into the syllabus."*

Time limitations and rigid curricular structures were also cited as significant barriers. Participants described how packed schedules and inflexible course designs curtailed opportunities for experimentation and inquiry, reinforcing a reliance on traditional lecture formats. A faculty member summarized this challenge: *"Lack of opportunity due to limited time and curricular factors."* These constraints were seen as systemic issues that limit the integration of scientific literacy into classroom practice.

4.2.2 Dominance of Traditional Approaches over Active Learning Strategies

Participant responses revealed a dominant reliance on traditional, lecture-based instruction, with only sporadic implementation of active learning strategies. Preservice teachers consistently described their classroom experiences as heavily lecture-driven, often followed by worksheets or quizzes. One PST noted, *"The lessons are mostly lectures, then followed by worksheets or quizzes,"* while another remarked, *"We sometimes have hands-on activities, but only simple ones because we don't have complete materials in the lab."* These accounts highlight the limited opportunities for experiential learning, which are essential for cultivating scientific literacy.

Faculty members similarly emphasized the centrality of lectures in their teaching practice, particularly for explaining complex scientific concepts. As one faculty participant explained, *"I use lectures to explain foundational concepts... break down complex ideas."* Another acknowledged the logistical challenges of sustaining laboratory work, stating, *"Since it's difficult to have laboratory activities all the time, my main strategy is lecture, problem solving."* While some faculty expressed openness to student-centered approaches, such as group work and inquiry-based projects, these methods were rarely integrated due to resource constraints and curricular pressures.

In sum, these accounts underscore the persistence of traditional pedagogical models in science education, with limited incorporation of active, student-centered strategies that are critical for developing higher-order thinking and scientific literacy.

4.3 Alignment of Science Syllabi with Scientific Literacy Goals

To complement the perspectives of preservice teachers and faculty, an analysis of 15 science course syllabi was conducted. The review revealed that scientific literacy is not explicitly defined or referenced within the syllabi. Instead, its presence is implied through selective learning objectives, instructional strategies, and assessment tasks that emphasize critical thinking, inquiry, and problem-solving. These implicit connections suggest that while elements of scientific literacy are embedded in course design, they are not systematically articulated or assessed. The absence of explicit language and structured integration may contribute to inconsistent skill development among PSTs, reinforcing the need for clearer curricular alignment with scientific literacy goals.

Consistent with PST and faculty perceptions, the analysis shows that scientific literacy is not explicitly defined or identified as an intended learning outcome in any course. This absence echoes arguments by Roberts (2007) and Fives et al. (2014), who note that when scientific literacy is not explicitly framed, its development becomes incidental rather than intentional. Although most syllabi demonstrate implicit alignment with selected competencies, very few address data literacy, statistical reasoning, or evaluation of information sources, which are central to contemporary frameworks (Gormally et al., 2012; OECD, 2019). This selective coverage indicates uneven emphasis across the dimensions of scientific literacy.

Table 5: Analysis of Science Course Syllabi for Scientific Literacy Indicators

Category	Key Findings	Frequency (n=15)	Evidence / Examples
1. Explicit Mention of SL	Scientific literacy (SL) is not explicitly defined or mentioned in the syllabi, but implicit alignment with SL competencies is evident through LOs, learning strategies and tasks.	0	*"No syllabus directly uses the term 'scientific literacy' in course descriptions, course outcomes, and assessments."*
2. Learning objectives linked to SL	Some objectives align with SL (critical thinking, inquiry skills).	6	*"Critique the ethical implications of genetic modifications and treatments in medical and biotechnological contexts."*
3. Pedagogical Strategies	Some strategies support SL development (inquiry-based learning, group activities/projects).	10 7 5	*Lecture* *Inquiry-based learning* *Problem-solving activities*
4. Assessment Methods	While traditional pen-and-paper tests dominate formative assessments, summative evaluations primarily employ performance-based tasks (demonstration, project, research).	11 2 2 1 4	*Pen-and-paper quizzes and examination* *Debate* *Case Study Analysis* *Community Proposal* *Problem-solving worksheets*

5. Discussion

The observed year-level progression in TOSLS scores reflects global and local patterns indicating that preservice teachers (PSTs) often exhibit borderline to low levels of scientific literacy, with gains across teacher education programs remaining modest (Altun-Yalcin et al., 2011; Cavas et al., 2013; Karamustafaoğlu et al., 2013; Ozdemir, 2010). Persistent weaknesses in identifying methods of inquiry and interpreting quantitative data (Sarini et al., 2024) mirror trends in the Philippine context, where PSTs report only moderate self-efficacy in teaching science (Flores, 2019). These findings suggest that PSTs' scientific literacy remains largely procedural focused on following steps rather than conceptual, which limits their ability to guide students toward deeper understanding and critical engagement (Fuentes et al., 2014; Karal Eyüboğlu, 2021; Lin et al., 2013).

Similar to international findings, Filipino PSTs continue to struggle with applying scientific reasoning to real-world socio-scientific issues, a concern given that global benchmarks such as PISA emphasize evidence-based reasoning and data interpretation (Karışan & Cebesoy, 2018; Walag et al., 2022). These results underscore the need for teacher education programs to intentionally cultivate conceptual understanding, inquiry proficiency, and critical evaluation skills (Avery & Meyer, 2012; Bacanak & Gökdere, 2009).

Qualitative findings further illuminate the systemic and instructional barriers that constrain scientific literacy development. Limited access to laboratories, instructional tools, and updated materials was consistently cited by PSTs and faculty as a major impediment to inquiry-based practice - echoing evidence that inadequate resources diminish engagement and conceptual growth (Abas & Marasigan, 2020; Colaler et al., 2025; Juanico et al., 2021). Pedagogical challenges, particularly the dominance of lecture-based instruction and the lack of professional development, reflect broader critiques of traditional science education, where passive delivery restricts meaningful learning (Hofstein & Lunetta, 2004). Structural constraints including time pressures, rigid curricula, and accountability measures further limit opportunities for inquiry, with studies showing that standardized testing and insufficient teacher preparation hinder the integration of literacy and inquiry practices (Hollenweger, 2023; Scott et al., 2018; Shah et al., 2019; Teig et al., 2019). These interconnected barriers suggest that improving PSTs' scientific literacy requires more than individual skill-building; it demands institutional reforms that provide adequate resources, coherent frameworks, and curricular space for active science teaching.

Syllabi analysis reinforced these findings, revealing that scientific literacy is only implicitly integrated into course design. While some learning objectives such as those emphasizing ethical reasoning align with literacy-related competencies (Bybee, 2010), their inclusion is inconsistent. Pedagogical strategies like inquiry-based learning and Socratic questioning appear sporadically, reflecting the broader reliance on lecture-based methods (Kember, 2009; Urdanivia Alarcon et al., 2023; Zion & Mendelovici, 2012). Assessment practices showed a mixed profile: formative tasks were dominated by pen-and-paper tests, while summative assessments increasingly incorporated debates, projects, and case studies, approaches known to foster inquiry and higher-order reasoning (Del Rosario & Chua, 2023; Gratchev, 2023). These findings echo the critique that science education often assumes literacy outcomes without explicitly embedding them in curricular frameworks (Chang et al., 2024; Roberts, 2011; Sermona et al., 2022). Coherent development of scientific literacy requires intentional alignment of objectives, pedagogy, and assessment across teacher education programs.

To address these gaps, a shift toward frameworks that embed authentic inquiry, collaboration, and real-world problem solving is essential. One promising approach is the integration of citizen science into preservice teacher education. This approach enables PSTs to engage with authentic data, apply scientific reasoning, experience science as a socially relevant and collaborative endeavor, and partner with researchers to mitigate resource limitations (Ballard et al., 2017; Bonney et al., 2009; Gray et al., 2012). The integration of such approach into the curriculum may help build a stronger foundation for future educators and contribute to reversing the trend of low scientific literacy reflected in large-scale assessments such as PISA

6. Conclusion

Preservice teachers' scientific literacy development emerges as fragmented, marked by partial proficiency across key competencies and limited opportunities to engage in authentic inquiry and research practice. Faculty perspectives underscore structural barriers, including inadequate laboratory facilities, insufficient learning resources, and time constraints, while also acknowledging the imperative to cultivate higher-order skills such as critical thinking and problem-solving. Syllabus analysis reinforces this picture, revealing that although elements of scientific literacy are present, they are inconsistently and implicitly embedded rather than systematically integrated across courses.

Thus, the findings highlight the need for more explicit, coherent, and intentional integration of scientific literacy within preservice teacher education programs, particularly in relation to scientific inquiry, data interpretation, and real-world application of science. The identified skill gaps, learning experiences, and curricular patterns suggest that instructional frameworks which more deliberately connect classroom learning with authentic scientific engagement warrant further investigation. Future research may explore the design and implementation of frameworks or approaches such as citizen science, interdisciplinary inquiry, or community-based research to embed scientific literacy meaningfully into preservice teacher preparation. Such approaches may not only strengthen PSTs' conceptual and procedural understanding but also enhance their capacity to foster scientific literacy in diverse classroom contexts. In addition, future research may also involve larger and more diverse PSTs across multiple institutions.

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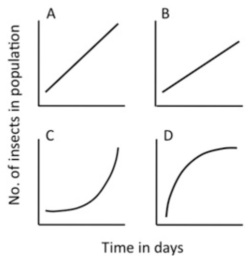
Appendices
Appendix A

Test of Scientific Literacy Skills
[Adapted from Gormally, Brickman and Lutz (2012)]

Directions: There are 30 multiple-choice questions. Encircle your correct answer. You will have about 40 minutes to work on the questions. Be sure to answer as many of the questions as you can in the time allotted. Try your best and be honest. Your honest answers will help the researcher develop learning strategies and activities to enhance your scientific literacy skills.

1. Which of the following is a valid scientific argument?
   a. Measurements of sea level in Manila Bay taken this year are higher than normal; the average monthly measurements were almost 0.5 cm higher than normal in some areas. These facts prove that sea level rise is not a problem.
   b. A strain of rice was genetically engineered to lack a certain gene, and the plants were unable to produce grains. Introduction of the gene back into the mutant rice plants restored their ability to produce grains. These facts indicate that the gene is essential for rice grain production.
   c. A survey revealed that 34% of Filipinos believe that volcanic eruptions are caused by supernatural forces because of local folklore. This widespread belief is appropriate evidence to support the claim that volcanic activity is not related to tectonic plate movements.
   d. This year, the average temperature in the Philippines was 1.5°C higher than the long-term average, and the number of extreme weather events, such as typhoons, has increased. These facts indicate that climate change is occurring.
2. While conducting a research project on pest management in a local vegetable farm in Benguet, you observed a particular kind of insect damaging the crops. You collected data on the insect population over time (see table below). Which graph best represents the population growth of the insects?

Time (days)	Insect Population (number)
2	7
4	16
8	60
10	123



3. A study about life expectancy was conducted using a random sample of 1,000 participants from the Philippines. In this sample, the average life expectancy was 72.5 years for females and 66.3 years for males. What is one way that you can increase your certainty that women truly live longer than men in the Philippines' general population?
   a. Subtract the average male life expectancy from the average female expectancy. If the value is positive, females live longer.
   b. Conduct a statistical analysis to determine if females live significantly longer than males.
   c. Graph the mean (average) life expectancy values of females and males and visually analyze the data.
   d. There is no way to increase your certainty that there is a difference between sexes.

4. Which of the following research studies is least likely to contain a confounding factor (a variable that provides an alternative explanation for results) in its design?
    a. Researchers randomly assign participants to experimental and control groups. Females make up 35% of the experimental group and 75% of the control group.
    b. To explore trends in the spiritual/religious beliefs of students attending Philippine universities, researchers survey a random selection of 500 freshmen at a state university in Eastern Visayas.
    c. To evaluate the effect of a new diet program, researchers compare weight loss between participants randomly assigned to treatment (diet) and control (no diet) groups, while controlling for average daily exercise and pre-diet weight.
    d. Researchers tested the effectiveness of a new organic fertilizer on 10,000 rice saplings. Saplings in the control group (no fertilizer) were tested during the dry season, whereas the treatment group (fertilizer) were tested during the wet season.
5. Which of the following actions is a valid scientific course of action?
    a. A government agency in the Philippines relies heavily on two industry-funded studies in declaring a chemical found in plastics safe for humans, while ignoring studies linking the chemical with adverse health effects.
    b. Journalists in the Philippines give equal credibility to both sides of a scientific story, even though one side has been disproven by many experiments.
    c. The Department of Health (DOH) decides to alter public health messages about breastfeeding in response to pressure from a council of businesses involved in manufacturing infant formula.
    d. Several research studies conducted in Philippine universities have found a new herbal supplement to be effective for treating the symptoms of diabetes; however, the Food and Drug Administration (FDA) refuses to approve the supplement until long-term effects are known.

Background information for question 6-7.
Celia and Anton are discussing whether they should consider reducing the amount of meat in their diet for environmental reasons and switch to a more vegetable-based diet. They consider the following:

- It takes 326 sq metres to produce a kg of beef, 12 sq metres to produce a kg of poultry meat, 2.8 sq metres for rice, and less than 1 sq metre for many vegetables.
- Celia and Anton are aware that to maintain health, the food they eat needs to contain an appropriate balance of food types—protein, carbohydrates, and fats—as well as a variety of trace nutrients.

6. Celia and Anton are concerned about the environmental impact of meat production. Based on the data provided, which of the following statements best explains why reducing meat consumption, particularly beef, can significantly lower their environmental footprint?
    a. Beef production requires significantly more land per kilogram compared to poultry, rice, and vegetables, leading to higher deforestation and habitat loss.
    b. Beef contains more protein than poultry, rice, or vegetables, making it a less sustainable source of nutrition.
    c. Beef production emits less greenhouse gases compared to poultry and plant-based foods, but it uses more water.
    d. Beef is the only source of complete proteins, so reducing its consumption would require careful dietary planning.
7. Based on the data provided, which of the following plant-based diets would have the lowest environmental impact while still providing sufficient protein?
    a. A diet based on rice and corn, which are staple crops in the Philippines.
    b. A diet based on soybeans and mung beans, which are high in protein and require less land to produce than meat.

c. A diet based on wheat and potatoes, which are commonly grown in temperate regions.
d. A diet based on quinoa and chia seeds, which are imported superfoods but require less land than meat.

8. Creators of the Shake Weight, a moving dumbbell, claim that their product can produce "incredible strength!" Which of the additional information below would provide the strongest evidence supporting the effectiveness of the Shake Weight for increasing muscle strength?
    a. Survey data indicates that on average, users of the Shake Weight in the Philippines report working out with the product 6 days per week, whereas users of standard dumbbells report working out 3 days per week.
    b. Compared to a resting state, users of the Shake Weight had a 300% increase in blood flow to their muscles when using the product.
    c. Survey data indicates that users of the Shake Weight in the Philippines reported significantly greater muscle tone compared to users of standard dumbbells.
    d. Compared to users of standard dumbbells, users of the Shake Weight were able to lift weights that were significantly heavier at the end of an 8-week trial conducted in a gym in the Philippines.
9. Which of the following is not an example of an appropriate use of science?
    a. A group of scientists in the Philippines were asked to review grant proposals for environmental research. They based their funding recommendations on the researcher's experience, project plans, and preliminary data from the research proposals submitted.
    b. Scientists are selected to help conduct a government-sponsored research study on the effects of deforestation in the Philippines based on their political beliefs.
    c. The Department of Environment and Natural Resources (DENR) reviews its list of protected and endangered species in response to new research findings.
    d. The Commission on Higher Education (CHED) stops funding a widely used science education program after studies show limited effectiveness in improving student performance.

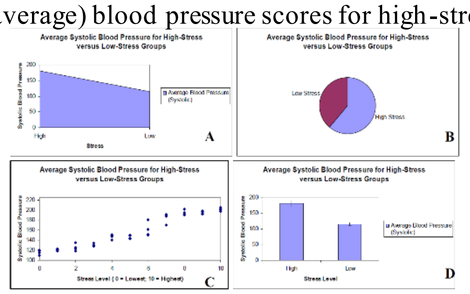
10. Your interest is piqued by a story about human pheromones on the news. A Google search leads you to the following website:

For this website (Eros Foundation), which of the following characteristics is most important in your confidence that the resource is accurate or not.
    a. The resource may not be accurate, because appropriate references are not provided.
    b. The resource may not be accurate, because the purpose of the site is to advertise a product.
    c. The resource is likely accurate, because appropriate references are provided.
    d. The resource is likely accurate, because the website's author is reputable.

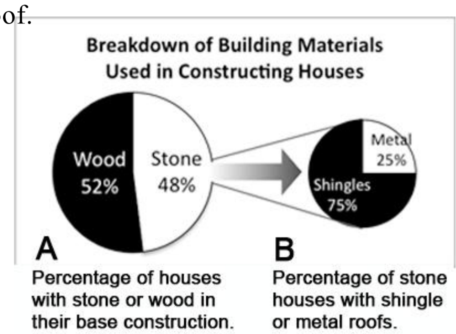
Background for questions 11 – 14: Use the excerpt below (modified from a recent news report) for the next few questions.

"A recent study, following more than 2,500 Filipinos for 9+ years, found that people who drank diet soda every day had a 61% higher risk of vascular events, including stroke and heart attack, compared to those who avoided diet drinks. For this study, Dr. Maria Santos' research team randomly surveyed 2,564 Filipinos about their eating behaviors, exercise habits, as well as cigarette and alcohol consumption. Participants were also given physical check-ups, including blood pressure measurements and blood tests for cholesterol and other factors that might affect the risk for heart attack and stroke. The increased likelihood of vascular events remained even after Santos and her colleagues accounted for risk factors, such as smoking, high blood pressure, and high cholesterol levels. The researchers found no increased risk among people who drank regular soda."

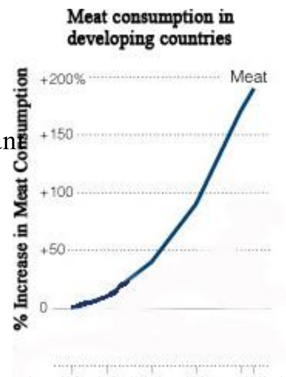
11. The findings of this study suggest that consuming diet soda might lead to an increased risk for heart attacks and strokes. From the statements below, identify additional evidence that supports this claim:
    a. Findings from an epidemiological study suggest that residents of Metro Manila are 6.8 times more likely to die of vascular-related diseases compared to people living in other Philippine regions.
    b. Results from an experimental study demonstrated that individuals randomly assigned to consume one diet soda each day were twice as likely to have a stroke compared to those assigned to drink one regular soda each day.
    c. Animal studies suggest a link between vascular disease and consumption of caramel-containing products (an ingredient that gives sodas their dark color).
    d. Survey results indicate that people who drink one or more diet sodas each day smoke more frequently than people who drink no diet soda, leading to increases in vascular events.
12. The excerpt above comes from what type of source of information?
    a. Primary
    b. Secondary
    c. Tertiary
    d. None of the above
13. The lead researcher was quoted as saying, "I think diet soda drinkers need to stay tuned, but I don't think that anyone should change their behaviors quite yet." Why didn't she warn people to stop drinking diet soda right away?
    a. The results should be replicated with a sample more representative of the Philippine population.
    b. There may be significant confounds present (alternative explanations for the relationship between diet sodas and vascular disease).
    c. Subjects were not randomly assigned to treatment and control groups.
    d. All of the above
14. Which of the following attributes is not a strength of the study's research design?
    a. Collecting data from a large sample size.
    b. Randomly sampling residents of Metro Manila.
    c. Randomly assigning participants to control and experimental groups.
    d. All of the above.
15. Researchers found that chronically stressed individuals have significantly higher blood pressure compared to individuals with little stress. Which graph would be most appropriate for displaying the mean (average) blood pressure scores for high-stress and low-stress groups of people?



Background for question 16: Energy efficiency of houses depends on the construction materials used and how they are suited to different climates. Data was collected about the types of building materials used in house construction (results shown below). Stone houses are more energy efficient, but to determine if that efficiency depends on roof style, data was also collected on the percentage of stone houses that had either shingles or a metal roof.



16. What proportion of houses were constructed of a stone base with a shingled roof?
    a. 25%
    b. 36%
    c. 48%
    d. Cannot be calculated without knowing the original number of survey participants.
17. Which of the following is the most accurate conclusion you can make from the data in this graph?



    a. The largest increase in meat consumption has occurred in the past 20 years.
    b. Meat consumption has increased at a constant rate over the past 40 years.
    c. Meat consumption doubles in developing countries every 20 years.
    d. Meat consumption increases by 50% every 10 years.
18. Two studies estimate the mean caffeine content of a popular energy drink in the Philippines. Each study uses the same test on a random sample of the energy drink. Study 1 uses 25 bottles, and Study 2 uses 100 bottles. Which statement is true?
    a. The estimate of the actual mean caffeine content from each study will be equally uncertain.
    b. The uncertainty in the estimate of the actual mean caffeine content will be smaller in Study 1 than in Study 2.
    c. The uncertainty in the estimate of the actual mean caffeine content will be larger in Study 1 than in Study 2.
    d. None of the above.
19. For scientists to determine whether the increasing frequency of extreme weather events (typhoons, floods) in the Philippines is caused by climate change, which one or more of the following would be considered important to establishing a strong case?
    I. Providing a scientific explanation for how climate change influences weather patterns in the Philippines.
    II. Researching public awareness and attitudes toward climate change and disaster preparedness.
    III. Showing that the increase in greenhouse gas emissions is consistent with the rise in extreme weather events.
    IV. Developing models that predict how climate change will affect the frequency and intensity of typhoons in the Philippines.
    V. Showing how weather patterns in the Philippines have historically fluctuated.

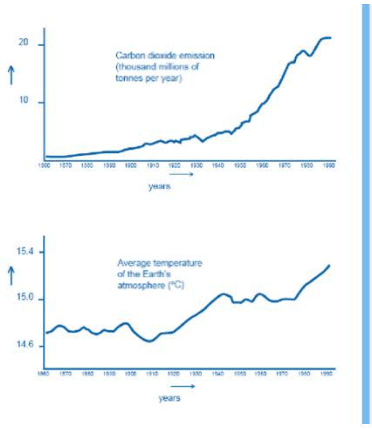
    a. I, III, and IV
    b. I only
    c. I and IV
    d. IV only

For items 11-14.

THE ENHANCED GREENHOUSE EFFECT: FACT OR FICTION?

The energy that sustains most living things on Earth comes from the sun's radiation. The Earth's atmosphere acts like a protective blanket around our planet, allowing the sun's radiation to pass through and absorbing some of the energy radiated back from Earth that would otherwise escape.
As a result of this, the average temperature of the Earth's atmosphere is higher than it would be if there were no atmosphere to trap the heat energy. The Earth's atmosphere thus has a similar effect to a greenhouse where the glass of the greenhouse traps heat energy from the sun and keeps the inside warm.
The data indicate that the average temperature of the Earth's atmosphere has significantly increased over the last century. The reason for this average temperature increase is said to be because of increased atmospheric carbon dioxide, which causes the atmosphere to more effectively trap heat – the greenhouse effect is thus enhanced by CO2.
André, a student, becomes interested in the possible relationship between the average temperature of the Earth's atmosphere and carbon dioxide emission on Earth. He comes across two graphs on a government website showing the average temperature of the Earth's atmosphere and carbon dioxide emissions over time. **He concludes that the increase in average temperature is certainly due to the increase in carbon dioxide emissions**. Another student, Jeanne, disagrees with André's conclusion after comparing the two graphs.

20. What about the graphs supports André's conclusion?
    a. Both graphs show a steady increase over time, suggesting a correlation between carbon dioxide emissions and average temperature.
    b. The graphs show that carbon dioxide emissions have decreased while average temperature has increased.
    c. The graphs indicate that other factors, such as solar radiation, are responsible for the temperature increase.
    d. The graphs show no relationship between carbon dioxide emissions and average temperature.



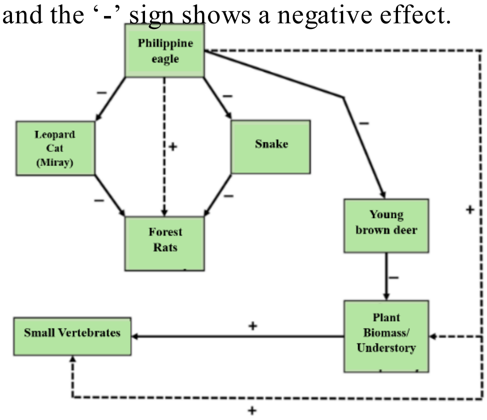
21. Give an example of a part of the graphs that does not support André's conclusion.
    a. A period where carbon dioxide emissions increased but average temperature remained constant.
    b. A period where both carbon dioxide emissions and average temperature decreased simultaneously.
    c. A period where average temperature increased without a corresponding increase in carbon dioxide emissions.
    d. All of the above.
22. Name one other factor that could have caused the mean temperature on the Earth to vary:
    a. Increased solar radiation due to changes in the sun's activity.
    b. Deforestation in the Amazon rainforest.
    c. Volcanic eruptions releasing large amounts of ash and sulfur dioxide into the atmosphere.
    d. All of the above.
23. For scientists to decide whether the rise in average temperatures in the Philippines is caused by increased emissions of carbon dioxide, which one or more of the following would be considered important to establishing a strong case?
    I. Providing a scientific explanation for how carbon dioxide affects the Earth's temperature.

II. Researching public attitudes toward climate change and renewable energy policies in the Philippines.
III. Showing that the increase in carbon dioxide in the atmosphere is consistent with the increase in human activities such as industrialization and deforestation.
IV. Developing models that predict how the increase in atmospheric carbon dioxide will impact typhoon frequency and intensity in the Philippines.
V. Showing how the temperature of the Earth has historically fluctuated due to natural causes.

a. I and II
b. I and III
c. I, III and IV
d. all of the above

For questions 20-21:

In the Mount Apo Natural Park, Philippines, the introduction of invasive species has changed the biodiversity. It has been suggested that if the Philippine eagle (a native predator) were reintroduced, it would alter the balance of the ecosystem. The diagram below shows how reintroducing the Philippine eagle might do this. The solid lines indicate direct effects, and the dotted lines indicate indirect effects. The '+' sign shows a positive effect, and the '-' sign shows a negative effect.



24. Based on the diagram, which of the following is the most likely outcome of reintroducing the Philippine eagle into the Mount Apo Natural Park ecosystem?
    a. The population of Forest rats will decrease.
    b. The number of small vertebrates will increase.
    c. The number of large herbivores (brown deer) will decrease.
    d. The plant biomass will increase.

c.

25. Which of the following is shown by the diagram?
    a. Leopard cat and snake populations will decrease because they are preyed on by the Philippine eagle.
    b. The population of forest rats will increase so the numbers of leopard cats and snakes will increase.
    c. Philippine eagles will not have direct effects on the numbers of leopards and snakes and large herbivores (brown deers).
    d. Plant biomass will increase because Philippine eagle will increase the number of herbivores.
26. Your doctor prescribed you a new drug for a common health condition in the Philippines. The drug has some significant side effects, so you decide to research its effectiveness compared to similar drugs on the market. Which of the following sources would provide the most accurate and reliable information?
    a. The drug manufacturer's pamphlet or website.
    b. A special feature about the drug on a popular Filipino TV news program.
    c. A peer-reviewed research study conducted by independent researchers.
    d. Information from a trusted friend who has been taking the drug for six months.
27. You've been doing research to help your grandmother understand two new drugs for osteoporosis, a condition common among elderly Filipinos. One publication, the Philippine Journal of Bone and Joint Health, contains articles with data only showing the effectiveness of one of these new drugs. A pharmaceutical company funded the production of the journal, and most advertisements in the journal are for this company's products. In

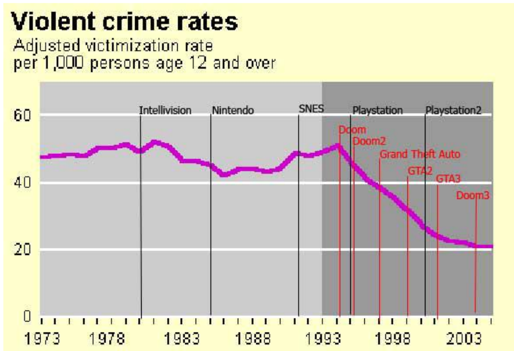
your searches, you find other articles that show the same drug has only limited effectiveness.

Pick the best answer that would help you decide about the credibility of the Philippine Journal of Bone and Joint Health:

a. It is not a credible source of scientific research because only studies showing the effectiveness of the company's drugs were included in the journal.
b. It is not a credible source of scientific research because there were advertisements within the journal.
c. It is a credible source of scientific research because the publication lists reviewers with appropriate credentials who evaluated the quality of the research articles prior to publication.
d. It is a credible source of scientific research because the studies published in the journal were later replicated by other researchers.

Background information for question #27.
A videogame enthusiast argued that playing violent video games (Doom, Grand Theft Auto) does not cause increases in violent crimes as critics often claim. To support his argument, he presents the graph below. He points out that the rate of violent crimes has decreased dramatically, beginning around the time the first "moderately violent" video game, Doom, was introduced.

28. Considering the information presented in this graph, what is the most critical flaw in the blogger's argument?



a. Violent crime rates appear to increase slightly after the introduction of the Intellivision and SNES game systems.
b. The graph does not show violent crime rates for children under the age of 12, so results are biased.
c. The decreasing trend in violent crime rates may be caused by something other than violent video games
d. The graph only shows data up to 2003. More current data are needed.

29. A new gene test developed by researchers at the University of the Philippines shows promising results in providing early detection for colorectal cancer, one of the leading causes of cancer-related deaths in the country. However, 5% of all test results are false positives; that is, the test indicates that cancer is present when the patient is, in fact, cancer-free.
Given this false positive rate, how many people out of 10,000 would have a false positive result and be alarmed unnecessarily?
a. 5 b. 35 c. 50 d. 500

30. Researchers interested in the relation between River Shrimp (Macrobrachium) abundance and pool site elevation, presented the data in the graph below. Interestingly, the researchers also noted that water pools tended to be shallower at higher elevations.

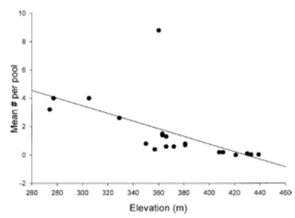


Fig. 3. Relationship between total abundance of *Macrobrachium* (1988–2002) and elevation in Quebrada Prieta.

Which of the following is a plausible hypothesis to explain the results presented in the graph?
a. There are more water pools at elevations above 340 meters because it rains more frequently in higher elevations.
b. River shrimp are more abundant in lower elevations because pools at these sites tend to be deeper.
c. This graph cannot be interpreted due to an outlying data point.
d. As elevation increases, shrimp abundance increases because they have fewer predators at higher elevations.

Appendix B

Semi-Structured FGD Questions

1. Faculty members handling Science courses to BSED Science major students

Questions	Responses
Part I. Background and Understanding of Scientific Literacy	
1. How do you personally define scientific literacy?	
2. How would you describe the current level of scientific literacy among the BSED Science students based on your observations and experiences?	
Part II. Teaching Practices, Challenges and Suggestions	
1. What do you think are the key strengths and challenges faced by preservice science teachers in terms of scientific literacy?	
2. What specific challenges have you encountered when trying to develop the scientific literacy of your BSED Science students?	
3. What instructional strategies or approaches do you usually used in teaching BSED Science students?	
4. What changes or interventions would you recommend to better support the development of scientific literacy among preservice teachers?	

2. Pre-service science teachers (BSED Science students)

Questions	Responses
Part I. Understanding and Personal Experience of Scientific Literacy	
1. How would you define scientific literacy, and why do you think it is important for pre-service teachers?	
2. What challenges have you faced in understanding or applying scientific concepts in your studies or daily life?	
3. How confident are you in your ability to teach scientific concepts to your future students, and what areas do you feel need improvement?	
Part II. Educational Program and Suggestions for Improvement	
1. How do you think your current education program is helping you develop scientific literacy? Are there any gaps?	
2. Can you share teaching methods or activities that you found helpful in improving your scientific literacy?	