Science Teachers' Use of English as a Second Language (ESL)-Derived Literacy Strategies

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ABSTRACT

The Philippines has emerged as a premier global hub for English language instruction, propelled by its exceptional English proficiency and commanding presence in the English as a Second Language (ESL) industry. Despite this strength, the Philippines continues to face significant challenges in science literacy and functional illiteracy. This underscores the urgent need to explore how science teachers, especially those with an ESL background, leverage their expertise in language instruction to support science learning. This study employed a descriptive qualitative research design that aims to explore the science teachers' use of ESL-derived literacy strategies in science instruction. Data from thirteen high school science teachers with ESL teaching backgrounds, were gathered through semi-structured interviews and analyzed using Braun and Clarke's (2019) reflexive thematic analysis. The findings show that science teachers perceive students' literacy skills as developing but constrained by language and comprehension barriers. In response, they employ ESL-derived literacy strategies such as pre-teaching vocabulary, visual and multimodal supports, and interactive language scaffolds to improve comprehension, make abstract concepts more concrete, boost confidence, and foster engagement, ultimately deepening conceptual understanding and retention in English-medium science lessons. However, these efforts are limited by time constraints, varying student proficiency, and strategy-content misalignment. These challenges highlight the need for accessible resources, extended instructional time, targeted professional development, and strategic implementation guidance. The study concludes that science teachers perceive that students' literacy skills are hindered by linguistic challenges, prompting teachers to use ESL-derived strategies to enhance understanding; however, the effectiveness of these strategies is impeded by structural and contextual factors, highlighting the need for stronger systemic support. Future research may explore the effectiveness of literacy-infused science instruction in the Philippine context.

Keywords: functional illiteracy, pre-teaching, multimodal support, language scaffolds, comprehension

INTRODUCTION

The Philippines has increasingly been recognized as a global hub for English language instruction, largely due to its high level of English proficiency and strong presence in the English as a Second Language (ESL) industry. Recent reports indicate that the country consistently ranks among the top in Asia in terms of English proficiency, reinforcing its reputation as a leading provider of ESL educators (Parungao, 2023). This linguistic advantage has enabled many Filipino teachers to develop pedagogical practices grounded in second language acquisition, particularly in teaching reading, writing, listening, and speaking skills. Studies further suggest that ESL teaching in the Philippine context emphasizes communicative competence and literacy development, which are essential for comprehension and meaning-making across disciplines (Andres-Kimkiman, 2025; Mercado, 2025).

Despite this strength, the Philippines continues to face significant challenges in science literacy and overall educational outcomes. Results from the Programme for International Student Assessment reveal that Filipino students rank among the lowest globally in science performance, indicating persistent gaps in conceptual understanding and scientific reasoning (OECD, 2019, 2023). Additionally, PSA's 2024 FLEMMS results show that nearly 3 in 10 individuals aged 10-64 is not functionally literate, meaning they struggle to comprehend and apply written and spoken information in real-life and academic contexts (Bordey, 2025). Moreover, reports from EdCom II further emphasize that around 18 million Filipinos finished high school despite being functionally illiterate. Learning poverty and low literacy levels remain pressing concerns in Philippine basic education. These findings suggest that difficulties in science learning are not solely due to the complexity of scientific concepts but are also closely linked to students' limited literacy skills.

This issue is further compounded by the multilingual nature of the Philippines, where learners navigate multiple languages in both home and school environments. While this linguistic diversity is a cultural asset, science instruction is predominantly delivered in English, creating an additional layer of cognitive demand for students. Research indicates that learning content subjects in a second language can hinder comprehension, particularly when students lack proficiency in academic English (Grapin & Llosa, 2021; Selvathurai & Ismail, 2024; Alhazmi & Alzahrani, 2025). Furthermore, the development of academic language, which includes discipline-specific vocabulary and discourse, is essential for understanding complex subjects such as science. Consequently, science becomes doubly challenging—not only because of its abstract concepts and technical terminology but also because students must process these ideas through a non-native language. In response, scholars advocate for the integration of literacy strategies within content instruction, including explicit vocabulary teaching, scaffolding, and guided reading, to support comprehension and conceptual understanding (Gao et al., 2022; Collins & Lasky, 2025). The Cognitive Academic Language Proficiency (CALP) model further explains that mastery of academic language is crucial for higher-order thinking and subject comprehension. This framework provides a strong foundation for integrating ESL-derived literacy strategies into science instruction.

Given these considerations, there is a growing need to examine how science teachers—particularly those with ESL teaching backgrounds—leverage their expertise in language instruction to support science learning. While existing literature affirms the effectiveness of literacy-based approaches in enhancing conceptual understanding, there remains limited research on how ESL-derived strategies are applied in science classrooms, especially in the Philippine context. Thus, this study aims to identify the ESL-driven literacy strategies teachers integrate into science instruction, understand the reasons, examine the challenges, and gather recommendations for improving these practices. Through this inquiry, the study seeks to contribute to the development of more responsive and linguistically inclusive science teaching practices that address both literacy and content learning needs.

Statement of the Problem

This study explores the science teachers' use of English as a Second Language (ESL)-derived literacy strategies in science instruction. Specifically, it seeks to answer the following questions:

1. How do science teachers perceive students' literacy skills (e.g. reading, writing, listening, speaking, comprehension) in science lessons?
2. What literacy strategies from their ESL teaching experience do science teachers integrate into science instruction?
3. Why do science teachers perceive that these ESL-derived literacy strategies effective in supporting students' understanding of science concepts?
4. What challenges do science teachers encounter in implementing ESL-derived literacy strategies in science lessons?
5. What suggestions do science teachers offer for improving ESL-derived literacy strategies in science instruction?

METHODOLOGY

Research Design

This study employed a descriptive qualitative research design to explore how science teachers integrate English as a Second Language (ESL)-derived literacy strategies into science instruction. This design was chosen to provide an in-depth understanding of teachers' perceptions, instructional practices, challenges, and suggestions within their real-world teaching context. By focusing on the descriptive experiences of teachers, the study captures detailed insights into the ways ESL teaching expertise informs literacy support in science classrooms. Data were analyzed using thematic analysis following the framework of Braun and Clarke (2019), which allowed for systematic identification and interpretation of patterns and themes emerging from teachers' responses.

Locale of the Study

The study was conducted in selected public and private high schools within Bukidnon. Schools were not selected based on geographic location alone but rather on the presence of science teachers who met the study's criteria: having ESL teaching experience and actively teaching science in high school.

Participants of the Study

The Participants of the study consisted of thirteen (13) high school science teachers selected using purposive sampling, to ensure that they were appropriate and relevant for the purpose of the study. The participants were chosen based on the following criteria: currently teaching science, possessing formal training or prior experience in ESL instruction, and willing to discuss their classroom practices. The number of participants was chosen to allow in-depth exploration while capturing diverse perspectives, guided by data saturation to ensure sufficient information for identifying recurring themes.

Research Instrument

Data were collected through semi-structured interview questionnaire, which provided the flexibility for teachers to elaborate on their practices and perceptions while allowing the researcher to probe for clarity and additional detail. The questionnaire was reviewed by three practitioners to ensure its validity. A certification of validity was then given as a sign of approval.

Data Gathering Procedure

Permission to conduct the study was obtained from school authorities, and participants were briefed on the study's objectives, procedures, and ethical considerations. Interviews were scheduled at times convenient for the teachers and conducted in a supportive environment to encourage open sharing. Due to geographical and time constraints, some participants chose to complete the interview through Google Forms. Interviews were audio-recorded with participants' consent to ensure accurate transcription, after which recordings were transcribed verbatim and translated to facilitate accurate analysis. The process was carried out until data saturation was reached, providing a strong foundation for extracting and defining key themes.

Data Analysis

Transcribed interviews were analyzed using Braun and Clarke's (2019) reflexive thematic analysis, which emphasizes the researcher's active role in interpreting the data. The process involved familiarization with the transcripts, generating initial codes, identifying and developing themes, reviewing and refining them, and defining and naming key patterns before producing the final report. This approach allowed the researcher to actively engage with the data, capturing recurring patterns, challenges, and insights related to the use of ESL-derived literacy strategies in science instruction. Direct quotations from participants were included to illustrate key findings and enhance the authenticity of the themes.

Research Ethics

Before implementing the study, ethical clearance was secured first from the Research Ethics Committee (REC) of Central Mindanao University, ensuring that all research activities conformed to adhered to established ethical guidelines. Afterward, a formal letter of approval was submitted to the Schools Division Superintendent and the respective schools. Informed consent was included, highlighting the purpose, data gathering procedures, and objectives of the study, allowing the participants to opt and decline the study. In accordance with RA 10173, otherwise known as the Data Privacy Act, anonymity was maintained, and all the information collected were kept confidential, stored securely, and used for educational purposes only.

RESULTS AND DISCUSSION

On the perception of science teachers in students' literacy skills in science lessons:

Theme: Developing Scientific Literacy Constrained by Language and Comprehension Barriers

This theme highlights that science teachers generally perceive their students' literacy skills as developing but constrained by language-related and comprehension challenges, particularly in understanding scientific vocabulary, interpreting texts and representations, and expressing ideas clearly. Across reading, writing, listening, and speaking, students demonstrate basic or emerging abilities; however, their difficulty in processing English-based scientific language significantly affects their comprehension, problem-solving, and conceptual understanding in science lessons.

The participants' responses reveal that students' literacy challenges in science are primarily linked to scientific vocabulary, comprehension, and communication skills. Many struggle to interpret written problems, as Participant 1 noted that *"many students struggled when solving word problems… particularly in identifying the given information… they often tried to immediately compute without identifying the givens"*, while Participant 2 added that students *"have difficulty comprehending scientific terms in texts and tend to provide short, incomplete explanations"*. Difficulties also appear in interpreting diagrams and graphs, with Participant 3 observing struggles with tectonic maps and Participant 7 noting challenges in connecting text to visual representations. Language barriers, especially in multilingual contexts, further complicate understanding, as highlighted by Participant 4 that *"students have difficulties understanding science-related terms in English… these terms do not have a local language translation"* and Participant 9 describing a *"translation gap"*. Weak writing and speaking skills, along with lack of confidence, were also reported (Participants 5 and 13), and gaps in listening and following procedural instructions emerged in laboratory tasks (Participant 11). Overall, teachers consistently described students' literacy readiness as *"still developing"* or *"poor"* (Participants 1, 2, 5, 7, 8, 12, 13), indicating that literacy limitations significantly affect comprehension, problem-solving, and the ability to communicate scientific concepts effectively.

The findings indicate that students' developing literacy skills, particularly in English, strongly influence their engagement with science, highlighting the language-dependent nature of science learning. Empirical work shows that students' limited mastery of scientific vocabulary and discourse undermines their ability to comprehend science texts, articulate explanations, and engage in problem-solving. Science-specific vocabulary uniquely predicting science achievement and technical vocabulary deficits identified as a major barrier to understanding academic science content (Erikson et al., 2024; Corpuz et al., 2024; Wong et al., 2025). In multilingual contexts, the "translation gap" adds cognitive load, making language-sensitive instruction and scaffolding strategies such as visual aids and guided discussions essential for comprehension and communication (Putra et al., 2025; Yawiloeng, 2022). Overall, these findings underscore that supporting scientific literacy through explicit vocabulary teaching, multimodal learning, and discourse practices is critical to help students fully understand and apply science concepts.

On the ESL-derived literacy strategies teachers integrate into science instruction:

Theme: Pre-teaching Vocabulary, Visual Support, and Structured Language Scaffolds

The theme captures the specific literacy strategies that science teachers borrow from their ESL teaching experience to help students understand science content. It is all about how teachers intentionally use pre-teaching or scaffolding of scientific vocabulary, visual and multimodal supports, and structured interactive language activities to make science lessons more comprehensible and to enable students to express their understanding in English. Essentially, this theme describes what concrete strategies teachers implement, drawn from ESL pedagogy, to improve literacy and learning in science classrooms.

Across the thirteen participants, teachers consistently reported integrating three main ESL-derived literacy strategies into science instruction. Vocabulary scaffolding or pre-teaching was widely used, with Participant 1 sharing that she *"introduced key terms such as force, distance, work, power, and energy using simple definitions* *and everyday examples"* and asked students to explain them in their own words; Participant 5 explained terms *"using simple language, pictures, or examples"*; Participant 6 stated that she *"pre-teaches vocabulary and guides students to use the terms when discussing concepts"*, while Participants 7 and 13 also emphasized pre-teaching key vocabulary before new topics, and Participant 4 described using a word bank posted on the wall for review. Visual and multimodal supports complemented vocabulary strategies, as Participant 2 described using *"visuals to clarify complex ideas"*; Participant 3 connected vocabulary to diagrams and real-life examples; Participant 9 relied on YouTube videos and annotated diagrams; Participant 10 employed hand gestures and modeling; and Participant 13 used pictures and a water cycle diagram to support comprehension. Finally, structured language scaffolds and guided interaction were implemented to enhance engagement and expression, with Participant 3 applying think-pair-share with key vocabulary and guided questions; Participant 8 using questioning to encourage explanations; Participant 11 employing *"I can, You can, We can"* steps; Participant 12 incorporating grading of language and Concept Checking Questions (CCQ); and Participants 1 and 5 structuring problem-solving through a *"Given-Formula-Solution"* framework.

The strategies highlighted in the participants' responses are consistent with research-based best practices for supporting English learners in content areas. In a quasi-experimental study of Topal (2024), pre-teaching STEAM vocabulary before content lessons enhanced acquisition and application compared to post-teaching, stressing activation of prior knowledge for science success. Moreover, Visual and multimodal aids (e.g., diagrams, videos, drawings) effectively bridge linguistic gaps by providing non-verbal entry points to abstract science concepts, enhancing comprehension, vocabulary retention, and conceptual understanding (Romine et al., 2023; Candido & Cattaneo, 2025). Furthermore, Alvarez et al. (2023) found out that sentence frames and discussion scaffolds in science curricula helped emergent bilinguals articulate explanations of phenomena, integrating language practice with content goals for deeper understanding. Collectively, these strategies demonstrate that ESL-derived literacy practices such as explicit vocabulary instruction, multimodal support, and guided language scaffolds are actively adapted in science classrooms to enhance comprehension, engagement, and communication.

On the reasons science teachers perceive ESL-derived literacy strategies as effective in supporting students' understanding of science concepts:

Theme: ESL Literacy Strategies Bridge Linguistic and Abstract Barriers for Concrete Science Comprehension and Engagement

This theme encapsulates teachers' consensus that ESL-derived strategies such as pre-teaching vocabulary, visual aids, real-life examples, Total Physical Response (TPR), structured problem-solving, and guided discussions are effective because they transform abstract scientific concepts into accessible, concrete experiences, reduce language barriers, boost student confidence, and foster active participation, ultimately deepening conceptual understanding and retention in English-medium science lessons.

The teachers consistently highlighted the effectiveness of ESL-derived literacy strategies, noting their ability to enhance comprehension, make abstract scientific concepts more concrete and accessible, build student confidence, and increase engagement. Improved comprehension and clarity were emphasized by all participants, who noted that these strategies *"makes the content clearer, more visual"* (Participant 1), *"makes the lesson easier to understand"* (Participant 5), *"break down complex terms and ideas into simpler, understandable parts"* (Participant 6), *"make learning easier and more concise"* (Participant 8), and *"help students understand hard concepts through simplifying them"* (Participant 10). Concretizing abstract ideas emerged as another key rationale, with participants describing how strategies make concepts *"relatable"* (Participant 2), *"easier to understand"* (Participant 7), more *"accessible"* (Participant 13), and help "*build a solid conceptual foundation before they even learn the technical English terms"* (Participant 9). Increased confidence and active expression were also highlighted, as these strategies enabled students to become more confident in "*solving similar problems"* (Participant 1), *"explaining concepts in their own words"* (Participant 3), and *"interpreting diagrams and graphs, and explaining ideas using proper scientific terms"* (Participant 7). Finally, enhanced engagement and retention were consistently observed, with strategies reported to *"keep them engaged and interested… leading to more understanding"* (Participant 4), make students *"more active to listen and learn"* (Participant 10), foster participation in discussions (Participants 5, 6, and 13), and develop higher-order thinking by *"enhancing their critical thinking"* through language adjustments tailored to proficiency levels (Participant 12). Collectively, these responses demonstrate that ESL-derived literacy strategies effectively address the linguistic and conceptual barriers in science, supporting students' comprehension, confidence, engagement, and ability to interact meaningfully with scientific ideas.

These converging findings highlight that ESL-derived literacy strategies are perceived as effective because they directly address the linguistic and cognitive demands of science learning. Science is inherently language-intensive, requiring students to process unfamiliar vocabulary, complex sentence structures, and abstract concepts simultaneously; thus, ESL literacy strategies help reduce cognitive load and allow students to focus on conceptual understanding. This explains why participants consistently emphasized improved comprehension, as these strategies make content clearer, simpler, and more structured, aligning with research that shows explicit attention to academic language significantly enhances science learning (Gao et al., 2022; Yawiloeng, 2022; Topal, 2024; Collins & Lasky, 2025; Dancel & Lagura, 2026). Moreover, concretizing abstract concepts through visual, tangible, and relatable representations, supports deeper understanding and retention, consistent with multimodal learning principles that highlight the value of combining visual and verbal inputs in science education (Romine et al., 2023; Candido & Cattaneo, 2025). The increase in students' confidence and ability to express ideas further demonstrates that language support enables more meaningful participation in scientific discourse, reinforcing the interdependence of language development and content learning (Fuentesal-García et al., 2025). Additionally, the observed improvements in engagement, participation, and critical thinking suggest that these strategies not only support comprehension but also promote active learning and higher-order thinking by making instruction more accessible and responsive to students' proficiency levels. Overall, the findings confirm that ESL-derived literacy strategies function as essential pedagogical tools that effectively bridge language barriers, make abstract scientific concepts accessible, and foster deeper understanding, engagement, and communication in science classrooms.

On the challenges encountered by science teachers in implementing ESL-derived literacy strategies in science lessons:

Theme: Time Constraints, Learner Diversity, and Instructional Misalignment as Primary Barriers to ESL Strategy Implementation in Science

This theme captures science teachers' consensus that curricular time pressures, diverse English proficiency levels of students, and content-strategy mismatches form the core obstacles to embedding ESL-derived literacy strategies in science lessons, compounded by resource shortages and large classes that undermine consistent effectiveness despite recognized benefits.

Teachers' experiences indicate that implementing ESL-derived literacy strategies in science is challenging due to the competing demands of curriculum coverage, the diverse English proficiency of students, and the need to tailor strategies to different types of scientific content. Time constraints dominated, as participants noted *"science lessons often need to cover a lot of content"* (Participant 1), *"extra time it takes to prepare visuals… fast-paced curriculum"* (Participant 2), *"limited time to cover both the science content and the language support"* (Participant 3), *"explaining vocabulary and guiding discussions can take longer than planned"* (Participant 6), and *"limited class time and the need to cover a wide range of science content"* (Participant 13), highlighting the difficulty of balancing science content with language scaffolding. Diverse proficiency levels were also a universal concern, with participants observing *"large class sizes; it's harder to provide individual language scaffolding"* (Participant 1), *"students have different learning styles"* (Participant 5), *"everyone has the same learning techniques… diverse learners"* (Participant 11), and *"diverse students which means you also need to employ different strategies"* (Participant 12), showing the challenge of meeting heterogeneous learning needs. Uneven strategy fit further complicated implementation, as participants explained that *"not all science lessons are fit to be injected with ESL strategies"* (Participant 4), pre-teaching vocabulary sometimes supported abstract concepts but experiential learning was still needed (Participant 7), and gestures were *"not effective in higher levels"* (Participant 10). Additional barriers included classroom management (Participant 1), and school activity interruptions (Participant 8), reflecting the practical frustrations teachers face in applying ESL strategies consistently while maintaining content coverage.

These findings demonstrate that the implementation of ESL-derived literacy strategies in science is largely shaped by structural constraints and learner variability, particularly time limitations and diverse student needs. The dominance of time-related challenges reflects the tension between covering extensive science content and providing adequate language support, as teachers must simultaneously address conceptual understanding and language development within limited instructional time. This aligns with the study of Villabona and Cenoz (2021) and Dancel & Lagura, (2026), emphasizing that time constraints significantly hinder the integration of language scaffolds in science classrooms, as teachers must juggle extensive content coverage with development needs, often struggling to balance both and ultimately prioritizing content objectives due to limited instructional time. Moreover, the presence of diverse proficiency levels highlights the complexity of differentiated instruction in multilingual classrooms, where teachers must adapt strategies to meet varying linguistic and cognitive needs, which can dilute the effectiveness of a single approach if not carefully scaffolded (Goyibova et al., 2025; Dancel & Lagura, 2026). The issue of strategy-content mismatch further suggests that ESL-derived strategies are not universally applicable, particularly in highly abstract or advanced science topics that require experiential or hands-on learning beyond language support alone (Van Eijck et al., 2024). Overall, the findings indicate that although ESL-derived literacy strategies are valuable, their success in science classrooms is contingent upon teachers' ability to navigate time pressures, learner diversity, and contextual limitations, requiring flexible, adaptive, and well-supported instructional practices.

On the recommendations of science teachers for improving ESL-derived literacy strategies in science instruction:

Theme: Systemic Support for Resource Readiness, Time Allocation, and Training to Sustain ESL Strategy Integration

This theme reflects the thirteen science teachers' consensus that improving ESL-derived literacy strategies requires ready-made materials, extended instructional time, professional development/training, and strategic implementation guidance to overcome current barriers and embed language support seamlessly into science curricula.

All thirteen participants emphasized the need for ready-made instructional materials such as visual aids, diagrams, vocabulary banks, and multimedia tools to reduce preparation time and ensure consistency, with teachers noting the value of *"ready-to-use visual aids, diagrams, and graphic organizers"* (Participant 1), *"vocabulary guides, visual aids"* (Participant 3), and *"YouTube videos or animations"* (Participant 9). Time allocation emerged as a universal concern, with participants recommending dedicated lesson segments for literacy support, such as *"allocate more time within lessons specifically for literacy support"* (Participant 1) and *"more time for integrating literacy strategies"* (Participant 13), reflecting the challenge of balancing content coverage with language scaffolding. Participants also highlighted the importance of professional development and strategic guidance, including *"training or workshops on integrating ESL techniques"* (Participant 6) and *"professional development… combining language support with science"* (Participant 7), to equip teachers with the skills needed to integrate ESL strategies seamlessly into science instruction. Teachers additionally recommended practical strategies for classroom implementation, such as introducing key vocabulary before lessons, using questioning, visuals, and real-life examples, and applying simple, consistent approaches (Participants 1, 2, 5, 6).

These insights align with research emphasizing that successful integration of language support into content areas is not solely dependent on the strategies themselves but also on the structural and instructional conditions that enable their effective use. Blair et al. (2024) argue that teachers need adequate preparation, planning time, and pedagogical knowledge to balance language scaffolding with content delivery, especially in subjects like science that demand both conceptual understanding and technical vocabulary mastery. Similarly, Dancel & Lagura, (2026) highlights that language-sensitive instruction requires readily available resources, such as visual aids, graphic organizers, and multimodal materials, to reduce cognitive load and allow students to focus on learning rather than decoding complex terminology. Vadivel et al. (2021) and Rufaidah et al. (2024) further stresses that professional development and ongoing teacher support are critical in equipping educators with strategies to differentiate instruction according to students' language proficiency and learning needs.

Together, these studies reinforce the finding that without sufficient resources, structured instructional time, and teacher expertise, even well-designed ESL-derived literacy strategies may fail to achieve their intended impact. In the context of this study, systemic support emerges as a foundational requirement to overcome practical and pedagogical barriers, ensuring that ESL strategies are not only implemented consistently but also enhance comprehension, engagement, and conceptual understanding without compromising the breadth and depth of science learning.

CONCLUSIONS AND IMPLICATIONS

The study concludes that students' scientific literacy is currently limited by language-related and comprehension barriers, particularly regarding technical vocabulary, the interpretation of multimodal representations, and the clear expression of ideas. To navigate these challenges, science teachers successfully integrate ESL-derived strategies such as vocabulary scaffolding, visual aids, and structured language scaffolds which are perceived as effective because they reduce cognitive load and transform abstract concepts into accessible experiences. While these pedagogical tools significantly enhance student engagement, confidence, and conceptual understanding, their consistent application is frequently hampered by systemic constraints. The primary obstacles include intense curricular time pressures, the difficulty of differentiating instruction for diverse learner proficiencies, and a lack of instructional resources tailored for language-sensitive science teaching.

The findings imply that improving scientific literacy requires a shift from individual teacher efforts toward comprehensive systemic support. Educational institutions must prioritize the development and provision of ready-made multimodal resources, such as vocabulary banks and visual aids, to alleviate teacher preparation time and ensure instructional consistency. Furthermore, there is a critical need for targeted professional development that equips science educators with the pedagogical knowledge to integrate language scaffolding seamlessly with complex content delivery. Finally, curriculum designers should consider allocating dedicated instructional time for literacy support within science lessons to resolve the tension between content coverage and language development. By addressing these structural barriers, schools can create a learning environment where linguistic diversity does not hinder the mastery of scientific concepts.

RECOMMENDATIONS

To improve scientific literacy and overcome language-related barriers, several key strategies can be implemented:

Students should actively practice using technical vocabulary and interpreting multimodal representations, such as diagrams and graphs, to build the confidence necessary for expressing complex ideas.

Teachers should intentionally implement ESL-derived literacy strategies to bridge the linguistic gap between abstract science concepts and learner understanding. It includes pre-teaching key terms, utilizing visual supports like YouTube videos, and applying structured scaffolds like "think-pair-share".

Administrators must provide systemic support by organizing professional development training on language-sensitive instruction and ensuring access to ready-to-use instructional materials, such as graphic organizers and vocabulary banks, to reduce the preparation burden on staff.

Finally, curriculum developers must address structural constraints by allocating dedicated instructional time for literacy support and designing ready-made multimodal resources that cater to diverse English proficiency levels, ensuring that fast-paced content coverage does not undermine students' conceptual depth.

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