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Addressing Multilingual Learners' Language Needs Through Engaging Inquiry-Based Science

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Abstract

This article presents an overview of a 3-year series of workshops on teaching and providing multilingual learners (MLs) with access to science by utilizing effective language development strategies. The workshops were delivered to primary teachers in California and included three different modules: (a) Think and Question Like a Scientist, (b) Observe and Record Like a Scientist through Science Notebooking, and (c) Argue Like a Scientist. The activities showcase effective, research-based second language acquisition (SLA) strategies, including providing comprehensible input via paraphrasing, using visual and media resources, gestures, and the student's native language, and modeling tasks. Additionally, scaffolding academic language through personal dictionaries, sentence frames, and native language support constitutes some of the ideas shared. Detailed descriptions highlight the "how" of addressing the needs of MLs at a variety of proficiency levels.

Keywords: English learners, science, critical inquiry, English language development

1. Addressing Multilingual Learners' Language and Academic Needs Through Engaging Inquiry-Based Science

The purpose of this article is to provide ideas and activities for promoting English language development (ELD) through the integration of science and ELD strategies. These ideas are based on workshops conducted over a 3-year cycle and aimed at motivating teachers to use effective pedagogy with the intention of making content accessible to English learners. The authors also refer to English learners as multilingual learners (MLs) throughout the article to emphasize an asset-based view of the students rather than a deficit view, where the focus is on students' lack of English. However, for quotes, legislation, research, and report findings that originally used English Learners as the term, will be noted as EL(s).

These workshops were part of a grant initiative by the California Department of Education, involving five counties, two universities, and a science center. The initiative intended to assist school districts in implementing the EL Roadmap (Olsen, 2017). The overarching goals were to (a) develop systemic pathways toward multilingual school communities that affirm, welcome, and respond to a diverse range of assets and needs among MLs, (b) create a global workforce, and (c) prepare teachers equipped to serve a multilingual California. The ELD through science modules were developed and delivered through a partnership between one university and the city's Science Center.

The academic discipline of science was chosen as the focus of the grant's workshops due to the many language-rich opportunities students have as they communicate with one another about their personal observations and explorations. Furthermore, inquiry-based science of the type promoted by The Next Generation Science Standards (NGSS) provides a rich context for the development of language as students naturally involve themselves in examining the scientific phenomena they encounter daily. The Next Generation Science Standards (NGSS; National Research Council [NRC], 2013) were developed to support educators in their efforts to teach science with a deeper understanding for students. This objective encompassed instruction, addressing the three dimensions of science: crosscutting concepts, disciplinary content, and science and engineering practices. When students are exposed to learning science in a more holistic, inquiry-oriented way, they can exercise their sense of wonder while learning and using English in meaningful ways for academic purposes (NRC, 2013).

2. Supporting MLs' Meaningful Access to Quality Content Instruction

In the United States, ELs comprise approximately 10% of the student population or 5 million students. Spanish is the most common language, with approximately 75% of the total EL population (National Center for Education Statistics NCES, 2020). An English Learner is defined by the NCES as "An individual who, due to any of the reasons listed below, has sufficient difficulty speaking, reading, writing, or understanding the English language to be denied the opportunity to learn successfully in classrooms where the language of instruction is English or to participate fully in the larger U.S. society. Such an individual (1) was not born in the United States or has a native language other than English; (2) comes from environments where a language other than English is dominant; or (3) is an American Indian or Alaska Native and comes from environments where a language other than English has had a significant impact on the individual's level of English language proficiency." Moreover, English proficiency exists on a continuum of how well a student understands and communicates in listening, speaking, writing, and reading.

Over the past decades, a body of research and approaches has emerged in the field of second language acquisition (SLA), and teachers who support MLs in accessing the curriculum use a variety of these approaches. These methods provide MLs with "instruction that is comprehensible, relevant, and motivating . . . and explicitly emphasizes language and content objectives" (Herrera & Murry, 2006, p. 271). Methods like the cognitive academic language learning approach (CALLA) integrate subject matter learning, academic language development, and learning strategies, emphasizing learners' interactions with others grounded in the sociocultural theory model (Chamot & O'Malley, 1994). Sheltered instruction through the SIOP Model (Echevarria, Vogt & Short, 2008) and specially designed academic instruction in English (SDAIE; Cline & Necochea, 2003) incorporate theories of first and second language acquisition and effective approaches for English language and academic development (Cummins, 1999; Krashen & Terrell, 1983; Vygotsky, 1962).

Second language acquisition methods help scaffold language and content by incorporating strategies such as (a) using guarded or controlled vocabulary to avoid high-level vocabulary, particularly with beginner language learners; (b) providing extensive modeling, for example, by giving step-by-step instructions; (c) paraphrasing using simpler language at the students' proficiency levels or paraphrasing by providing higher-level academic language; (d) exploring contrast analysis, for instance, by explaining and using cognates; (e) implementing hands-on activities that include intentional and modified vocabulary; (f) providing a variety of context clues, such as photographs, drawings, realia, and videos shown effectively (e.g., in small segments or by using voice narration with simpler language); (g) offering primary language support when possible. These strategies help scaffold academic concepts and language to match the students' varying levels of linguistic and academic ability (Alexandrowicz, 2020). They also aid students in their cognitive academic language proficiency (CALP) development, which is the language learners must acquire to handle academic demands (Bresser & Fargason, 2013; Cummins, 1999).

Teachers play a crucial role in supporting learners' development and providing support structures to help students reach their next stage or level of understanding and ability, ultimately accessing curriculum content. By intentionally scaffolding for MLs, teachers ensure students receive comprehensible input, which is the basis for understanding new language in Tier 1 (i.e., high-frequency or basic vocabulary), Tier 2 (i.e., vocabulary appearing in different subject areas), and Tier 3 (i.e., vocabulary specific to a lesson or unit; Beck, McKeown, & Kucan n.d.; Hellman, 2018).

The EL Roadmap, approved in 2017 by the California State Board of Education, is a policy intended to provide guidance to local educational agencies (LEAs) on how to welcome, understand, and educate the diverse population of students who are ELs attending California public schools (Olsen, 2017) The EL Roadmap is built upon four principles:

(1) Assets-oriented and needs responsive schools

(2) Intellectual quality of instruction and meaningful access

(3) System conditions that support effectiveness

(4) Alignment and articulation within and across systems

The workshops focused on the second principle, intellectual quality of instruction and meaningful access, which integrates ELD and science strategies to enhance ELs' access to science content. During these workshops, teachers were shown how to implement scaffolds for students' ELD and use specific strategies (e.g., paraphrasing using realia, building background knowledge, and capitalizing on students' native languages) to provide MLs with better access to the curriculum. These strategies were modeled for teachers so that they could, in turn, support their students through inquiry-based science activities. These activities may include making observations, interpreting evidence, refining ideas, explaining findings, and helping one another develop new perspectives.

3. Science and MLs

In the U.S. educational system, the level of academic achievement among MLs, particularly in science, technology, engineering, and mathematics (STEM) subjects, has lagged, and MLs have not attained the same academic success as their English-proficient peers (Estrella, Au, Jaeggi, & Collins, 2018; Lee & Buxton, 2013). An examination of the National Assessment of Educational Progress science subtest reveals that multilingual learners (MLs) consistently score lower across all grade levels and are more likely to score below the basic level. These findings highlight the greater need for STEM education support among ML students than their non-ML peers (Genesee, Lindholm-Leary, Saunders, & Christian, 2005; Goldenberg, 2013; NCES, 2020.)

Traditionally, MLs have been marginalized in mainstream classrooms due to language barriers, attitudes toward them, and an inaccessible curriculum. The teaching of science is no exception. Abstract and highly technical scientific concepts and terminology present challenges for MLs as science requires high levels of academic language proficiency and discourse in speaking, listening, reading, and writing. For example, it demands a precise level of explanation for everyday phenomena (Morrison et al., 2020; Quinn, Lee, & Valdes, 2016). The active learning involved in inquiry instruction is believed to maximize meaningful learning opportunities for MLs by reducing the linguistic demands associated with traditional textbook and lecture-based learning (Estrella et al., 2018) in language at their proficiency level. Inquiry science starts with exploration and shared experiences, offering students a context to develop questions and authentically use data to analyze and generate new language (Weinburgh, Silva, Horak-Smith, Grouix, & Nettles, 2014). Inquiry-based science teaching and learning contrast with traditional methods such as direct instruction, which focuses on building facts like knowledge and uses a teacher-centered approach and highly structured guidance (Kirschner, Sweller, & Clark, 2006). The inquiry approach prompts MLs to communicate their understanding of scientific concepts and procedures, which may promote their oral and written language skills (August, Branum-Martin, Cardenas-Hagan, & Francis, 2009). Lee et al., (2019) also point to the rich opportunities for acquisition of academic language that NGSS provides for students with its emphasis on the practices employed by scientists and engineers. These inquiry approaches include asking questions, constructing explanations and argumentation. “In short, as learners use language to do science together, they develop their science understanding and English proficiency in tandem.,” (p. 320).

On the other hand, in the case of inquiry-based science, researchers have also identified various challenges ELs face in the science classroom, including the time required to develop academic proficiency (Cummins, 2000) and the context-bound nature of academic language (Brown & Ryoo, 2008). In a meta-analytic review of the effectiveness of inquiry-based science, Estrella et al. (2018) concluded:

Inquiry instruction has the potential to improve science learning and performance for not only English-proficient students but also ML students—albeit to a lesser extent. Although the learning benefits associated with inquiry instruction are compelling, our data suggest that ML students might require additional academic and linguistic support if they are to attain a level of science achievement that is on par with their English-proficient peers. (p. 17)

In addition, MLs may still have difficulty with cognitive loads in the hands-on, self-guided, and highly contextualized exploration methods characteristic of inquiry-based science. These methods may not provide sufficient structure and intentional teaching to scaffold and facilitate meaningful learning. Students often require prior knowledge to support discovery learning (Kirschner et al., 2006; Tobias & Duffy, 2009). Given the demands of inquiry-based science, teachers must receive preparation and professional development to support MLs—not only understanding science but also becoming scientists who formulate questions they can answer through exploration and experimentation.

4. English Language Development Through Science Workshops

This section presents three of the four workshops. Specific science concepts from the NGSS and ELD strategies intended to support language development and science comprehension are highlighted. The three workshops are: (a) Think and Question Like a Scientist, (b) Observe and Record Like a Scientist through Science Notebooking, (c) Argue Like a Scientist.

4.1 Module 1: Think and Question Like a Scientist

One of the foundational skills students need to acquire in learning science is how to think like a scientist, which includes asking and answering questions. These scientific questions lead to seeking answers systematically, with a focus on gathering evidence to support claims. The goals for Module 1 are:

(1) Understanding how crosscutting concepts link the different domains of science.

(2) Understanding how to use phenomena to encourage student questioning.

(3) Identifying ELD strategies to make science content accessible to MLs.

(4) Incorporating sub-element 2 of the EL Roadmap. (Olsen, 2017)

In Module 1, the ELD and science concepts presented include:

(1) Science Concept 1: Teachers can use natural phenomena to encourage student questioning and inquiry.

(2) ELD Concept 1: Teachers must model and provide scaffolds, such as sentence frames, that students can use to generate questions.

(3) Science Concept 2: Teachers engage NGSS crosscutting concepts to connect different domains of science (i.e., life, physical, earth, and space). The seven NGSS crosscutting concepts include patterns and cause and effect.

(4) ELD Concept 2: MLs need paraphrasing, visuals, and other forms of comprehensible input so they can identify and practice academic language used in different content areas and with multiple meanings.

4.1.1 Activity 1: Phenomenon—Rivers Flowing

In this activity, a teacher can share a time-lapse photograph of a river flowing where the phenomenon is the movement of a river and pose questions to students such as: Why does the river flow as it does? What caused it to go in that specific direction? Then, have students ask their own questions, as questioning is a significant aspect of learning from phenomena in general. It involves students creating questions about what interests them in that phenomenon.

Potential ELD Adaptations

(1) Teacher writes on chart paper or the board: “A phenomenon is an occurrence” and adds “Phenomenon = Occurrence” to emphasize equality. The teacher stresses that occurrence sounds similar to the Spanish word ocurrir for students who speak that language. Emphasize that “It is something that happens that we can see or ‘observe’” and write “Phenomenon = Occurrence = Something that happens that we can see.”

(2) The teacher shows a slide with an animation of a flowing river, asking, “What do you see here? What occurrence? What phenomenon?” while pointing to the explanations on the board. Students may respond using basic vocabulary such as “A river going down.” The teacher uses the language students provided and adds corresponding academic language, such as paraphrasing with “Yes, the river is moving or ‘flowing’ downward, changing the way it looks or ‘appearance.’”

(3) For students at the emerging proficiency level, the teacher emphasizes simple vocabulary like “river,” “water,” and “flows down,” while using gestures. The teacher asks, “How do you say ‘river’ (pointing to the river picture) in Spanish? In Korean? In Tagalog?” Students provide vocabulary in their native language, and the teacher adds it to the presentation slide with the flowing river.

(4) The teacher encourages students to ask questions using English or the second language, translating the latter to English using e-translators.

4.1.2 Activity 2: Phenomenon—Bioluminescence

Another phenomenon that could be presented to students is bioluminescence, which involves light produced by a chemical reaction within a living organism. Important background information teachers should be that certain life forms can undergo a chemical reaction within their bodies that generates a glowing effect, usually observed as blue. In the case of bioluminescent algae in the water, they contain chemicals enclosed within capsule-like structures in their bodies. When these algae are disturbed or touched, the membranes of these capsules undergo slight changes, leading to a reaction between the chemicals and resulting in a vivid flash of blue light. This phenomenon occurs at certain times of the year due to temperature variations. Teachers may show the YouTube video (https://www.youtube.com/watch?v=vOPliKfxk8Y).

After students have viewed the video, ask them what they wonder about. Here are some potential inquiries that may arise:

(1) I wonder what causes the water to light up when it gets splashed.

(2) I wonder why the water is turning blue.

(3) I wonder how long it stays illuminated.

(4) I wonder if there is some sort of electrical charge.

(5) I wonder if the water smells.

(6) I wonder how often this happens.

Students can be introduced to various phenomena through bioluminescence videos and photos or the students' experiences and personal observations. Once their curiosity is piqued, ask questions like, "What do you wonder about? What are you thinking about? What are you curious to know?" Engaging with these experiences requires the use of language. From there, guide students in addressing these questions, potentially by conducting experiments. Teaching using actual phenomena deepens their understanding of existing knowledge and fosters a greater curiosity and desire to seek answers to their questions.

Potential ELD Adaptations:

The teacher prompts students to "watch this video of a natural 'phenomenon' or 'occurrence,' 'something that happens' and think about questions you would like to ask."

(1) For students at emerging proficiency levels, pause the video on specific frames, point out the bioluminescence in the water, and use short phrases or sentences emphasizing the nouns and adjectives (e.g., "The water is sparkly or very bright; this phenomenon is called bioluminescence").

(2) For students at expanding proficiency levels, encourage them to write down their questions using the "I wonder" prompt. Model the process with a sentence like "I wonder if the water only looks bright at night." Write these statements on a chart or slide.

(3) For MLs at expanding and bridging proficiency levels, break down the word into its prefix, root, and suffix components. During experiments, teachers must explicitly point to objects, actions, and adjectives while carrying out the experiments so they provide basic vocabulary for emergent MLs. In addition, they need to paraphrase or explain tricky definitions and grammatical forms such as conditional tenses, long and complex sentences, idiomatic expressions, or transition words that more advanced MLs need to use in their writing.

4.1.3 Activity 3: Identifying Crosscutting Concepts Through Natural Phenomena

The NGSS crosscutting concepts identify seven foundational themes in each of the three scientific domains: physical science, earth and space science, and life science. They are: (1) Patterns; (2) Cause and effect; (3) Scale, proportion, and quantity; (4) Systems and system models; (5) Energy and matter; (6) Structure and function; (7) Stability and change.

Using these concepts repeatedly within each domain allows students to become familiar with the terms. This growing familiarity can enhance understanding for MLs and students with special needs: "It is essential that all students engage in using crosscutting concepts, which could result in leveling the playing field and promoting deeper understanding for all students" (NRC, 2013, p. 81).

Finally, teachers often find it challenging to integrate crosscutting concepts into their science lessons (Cooper, 2020). By examining the phenomena of a flowing river and bioluminescence through the lens of the NGSS crosscutting concepts, it becomes evident how easily teachers can design activities with the objective of developing students' skills in the different crosscutting concepts.

Flowing River. Several overarching concepts might be identifiable concerning the flowing river visual with its meanderings. Certainly, some patterns can be observed from the winding river. Additionally, there are causes and effects related to these flowing patterns. Furthermore, the entire river is a system. Mathematics could be used to investigate the scale, proportion, and quantity of the river's meanderings. The energy involved in the creation of this phenomenon can also be observed. Moreover, the structure and function of the river and the meanderings can be noted. Finally, like all systems, this system is subject to stability and change. In summary, teachers can easily integrate all seven crosscutting concepts through this simple science activity.

Bioluminescence. The phenomenon of bright glowing algae certainly sparks curiosity in children. The following examples show which crosscutting concepts might be incorporated into the aforementioned investigation of bioluminescence. Teachers may ask the following questions after students have received instruction on the crosscutting concepts:

(1) Can patterns be discerned in the glowing algae? Yes.

(2) Is there something causing the glow effect? Yes.

(3) Could we measure the scale, proportion, and quantity of this phenomenon? Yes.

(4) Is this phenomenon observed system-wide? Yes.

(5) Does an energy exchange occur in the algae matter? Yes.

(6) Does the glow represent something happening in the structure of the algae that could potentially alter the function? Yes.

(7) Lastly, does this phenomenon change over time? Yes.

Like the previous example, all seven crosscutting concepts fit nicely into this simple science activity. Older native English speakers and writers might be able to make these connections independently.

Potential ELD Adaptations:

For crosscutting concepts, teachers should ensure they provide a variety of examples and opportunities for practice with the concept before posing high-level questions. For each of the seven concepts, students must be given chances to acquire critical academic language and extensively practice identifying the concepts in context using video, literature, and hands-on experiences, among others. Before delving into cause and effect for bioluminescence, students engage in hands-on experiences such as using different substances to trigger chemical reactions, predicting whether different-density objects will sink or float, or simulating erosion by allowing water to flow over the landscape. The teacher might ask students to provide examples based on their experiences (e.g., when it rains, the street becomes smooth and wet, so we might slip and fall).

After exploring the crosscutting concept in real life, students will be better prepared to analyze the concept of cause and effect at a higher level of thinking and language, such as analyzing bioluminescence on video. Teachers may also encourage students to brainstorm ideas on how to replicate bioluminescence, which can be achieved using materials such as a glowing stick, sand, and water. By employing all scaffolding strategies, MLs can visualize the crosscutting concept in concrete ways and learn academic language. For example:

For MLs at the emergent or developing levels of proficiency, highlighting simple vocabulary such as “water” and “bright,” and paraphrasing cause and effect with “this happens (the water is bright or there is bioluminescence) because there are small bugs (bacteria or organisms) in the water that when moved light happens (bioluminescence).”

For students capable of producing written language and reading, teachers may use a two-column T-chart with “CAUSE: Something that makes something else happen” and “EFFECT: What happens because or ‘as a result’ of something else.” The teacher or students record a variety of examples provided during instruction. For the questions after the students have received instruction in the crosscutting concepts and taught the main academic language, the teacher would need to paraphrase with simpler language, such as verbs students may not be MLs with. For example:

Can patterns be discerned (i.e., found) in the glowing algae?

Does the glow represent (i.e., look like) something happening in the structure of the algae that could potentially alter (i.e., change) the function?

4.2 Module 2: Observe and Record Like a Scientist Through Science Notebooks

Having students record observations in science notebooks strengthens their science and literacy skills. Notebooks create opportunities for them to use speaking, thinking, and writing skills while engaging in scientific discourse and observing phenomena in the natural world. These advantages are particularly strong for MLs.

Research has shown that science notebooks support differentiated instruction for MLs through a variety of formats and strategies, such as tapping into prior knowledge, using the five senses, interacting with peers, and, if possible, providing primary language support. Teachers can also use notebooks to conference with students for assessment and guidance (Aschbacher & Alonzo, 2006). For MLs, science notebooks offer several benefits:

(1) Notebooks provide insights into students' understanding, misunderstandings, and thinking about content and language skills.

(2) MLs' recordings of their observations on inquiry-based investigations increase their understanding of science and academic vocabulary.

(3) Notebooks encourage students to communicate their understanding of science concepts.

(4) Teachers have opportunities to provide feedback and assess MLs.

(5) Keeping a written record is a tool for differentiating instruction.

(6) Students may write in their native language.

The goals for Module 2 are:

(1) Identifying strategies and formats for using notebooks with MLs.

(2) Exploring how to include collaborative skill development through observations.

(3) Making thinking visible to both students and teachers.

(4) Identifying strategies that promote critical thinking.

In Module 2, the ELD and Science concepts presented include:

Science Concept 1: Students can observe phenomena in the natural world and record them in words and drawings in their science notebooks.

ELD Concept 1: Notebooking benefits MLs as it may include collaborative and productive skill development through observations.

Science Concept 2: Recording and organizing data is a skill students must work on over time.

ELD Concept 2: MLs at different proficiency levels will increasingly use Tier 1, 2, and 3 vocabulary words over time to describe what they observe and record these observations.

4.2.1 Activity 1: Using the School Playground for Student Observations and Recording in Science Notebooks

The school playground provides an easily accessible outdoor venue for students to observe objects they find and record their observations and drawings in their science notebooks. The activity can be structured as follows: Take students outdoors to the playground and direct them to walk around with a partner and observe what they can see, hear, and touch. This introductory exercise will support building academic language. After observation, ask each student to find an "interesting" rock to bring indoors. Once in the classroom, have them sit at their desks and spend time observing their rock from all angles. Have them feel the rock's weight and note its texture. Then, have them open their science notebooks to a new page and draw their rock. Pencils work well for this task, allowing students to capture the rock's diverse textures and colors. Have them collaborate with their partners to describe their own rocks and ask them to include these written descriptions in their notebooks. Finally, collect all the rocks and place them in a bag, mixing them thoroughly before spreading them out on a table. Ask students to bring their science notebooks to the table one by one. Instruct them to identify their rock with reference to their drawings and descriptions. This activity demonstrates how science notebooks can benefit students in the following ways:

(1) Offering insights into students' understanding, misconceptions, and thinking about content and language skills.

(2) Recording observations of scientific phenomena.

(3) Promoting communication among students.

(4) Assessing students' grasp of content knowledge and language skills.

Potential ELD Adaptations

Notebooking requires MLs to know and be able to use descriptive vocabulary, specifically adjectives denoting color, hue, texture, and shape to describe objects. Teachers can develop a parts of speech chart (GLAD strategies, no date) with vocabulary categorized across five columns: Pronouns, Verbs, Adjectives, Nouns, that students can refer to while writing their descriptions. Involving the entire class in filling up the chart with words they are already familiar with is essential. The first column of the chart should include "I" and "We" (if students are observing in pairs or groups). The second column should contain verbs like "saw," "observed," and "noticed." The third column should list adjectives such as "soft," "sharp," "rough," "(colors)," "heavy," and "(shapes)." The fourth column should include nouns like "rock," "pebble," and "stone." The fifth column should comprise prepositional phrases like "on the playground," "on the grass," and "under the tree." Once the chart is displayed, the teacher can guide students in crafting sentences using different combinations of parts of speech. For instance, "I observed a sharp rock on the playground." Some effective practices for different levels of language proficiency include the following:

(1) For emerging to developing proficient writers, sentence frames can be provided to scaffold their writing.

(2) For more advanced writers, the teacher can model complex sentences such as "I observed a rock that was sharp, round, and rough around the edges, gray with white spots, under the tree."

(3) Advanced proficiency students should also learn academic vocabulary such as "hue," "texture," "record," and "notice." Prior acquisition of the encouraged vocabulary is essential for effective participation in these activities.

(4) Alternatively, a chart containing only adjectives could be created, ensuring all students understand the word meanings. If MLs are just beginning in listening and speaking, the teacher can provide comprehensible input by teaching basic or Tier 1 vocabulary, like "rock," "soft," "heavy/light," and "see/observe."

4.2.2 Activity 2: Using Our Senses for Observation

When we think about observation, the first thing that comes to mind for most people is what we can see. However, observations can be made using all five senses (vision, hearing, touch, smell, and taste), although the last two are less frequently used in classrooms. In this activity, teachers can play various sounds and have students listen, identify them, attempt to imitate the sounds, and finally record their observations of the sounds in their science notebooks. Describing sounds requires students to use additional academic language, such as "high/low," "loud/soft," "long/short," and "single creature/group of creatures."

Say to students: Listen to the following sounds and record what you hear in your notebooks.

Ask: What do you hear?

Teachers can refer to YouTube for sounds to use. Several examples are included:

(1) Insect sounds: https://www.youtube.com/watch?v=D6shA0yJ8W4

(2) Gray Tree Frog: https://www.youtube.com/watch?v=9bzotS1ow0Q

(3) Katydid: https://www.youtube.com/watch?v=_aRZXNAxrVM

(4) Croaking of a Great Blue Heron: https://www.youtube.com/watch?v=_tM3VqFeCd0

(5) Desert Rain Frog: https://www.youtube.com/watch?v=drkVaBWd0oY

Potential ELD Adaptations

Prioritizing activities that lower the affective filter for MLs should be a key focus for effective language acquisition and learning (Krashen & Terrell, 1983). Attempting to imitate animal and insect sounds after playing them incorporates humor, which helps reduce students' anxiety. For students with emergent proficiency, teachers should practice identifying different sounds with them to teach words like "high/low," "loud/soft," and "long/short" beforehand. By doing this before playing animal or insect sounds, MLs will be better prepared to participate in the activity. MLs developing proficiency can be provided with sentence frames such as "I heard a sound that was . . .[descriptive word] and may have been a . . . [insect/animal]" to assist them in recording their observations in their notebooks. Teachers can show pictures with written names of insects and animals, like cricket, frog, or heron, allowing students to guess or describe what they hear.

4.2.3 Activity 3: Recording and Organizing Data

Scientists not only observe but also need to record information for future reference. Science notebooks provide a designated space for student–scientists to make these recordings. However, pages and pages of observation notes are not easily comprehensible over time, and for this reason, data need to be organized. Numerous methods exist for organizing and recording data, including charts, graphs, and models/illustrations.

A straightforward classroom activity, repeatable with different prompts, involves showing students a picture (e.g., a photo of a bedroom). Allow them time to observe the picture and then ask them to describe or write what they see. Using a chart or digital spreadsheet, ask each student to contribute two items they observed. The teacher can add these to the chart or spreadsheet. Finally, ask the question to the students: How can we organize our list so that it is easier to understand? One possible response might be to group or categorize them. Ask them to help organize the different items into similar categories and model how to create a graph using one of the categories (e.g., things on the floor). Have them work with a partner to complete the graph with various categories of items observed in the room. This activity also offers an excellent opportunity to integrate math into the science/language lesson.

Potential ELD Adaptations

When involving beginning MLs in observing pictures, it is ideal to select culturally appropriate images. These images should include objects that students can relate to based on students' ages, socioeconomic statuses, or cultural backgrounds. Pictures that resonate with students facilitate language production in their native language, which the teacher or peers can then support in the second language. MLs must learn academic language like "categories" before engaging in the activity with the whole class (i.e., assuming their peers are already familiar with the concept). An effective way to teach categories is by using cutouts from catalogs or selecting pictures from digital sources like Pixabay (n.d.). Ask MLs how to group or "categorize" the items, such as clothing. Clothes can be grouped as women's, men's, children's, summer, winter, upper body, lower body, etc. MLs will also need to grasp academic terms like "graphs" and "charts," and when the teacher demonstrates how to create a graph, step-by-step instructions should be provided. In the case of the cutouts activity with clothes, students can physically place clothing items in a bag and construct the graph with the teacher's guidance.

4.3 Module 3: Argue Like a Scientist

This module supports the discovery of strategies to enhance student arguments using claims supported by evidence, real-world data, and opposing scientific views. Learning argumentation allows students to express their opinions and develop a deeper understanding of the content while also building critical language skills. Arguments are necessary because argumentation is one of the four intensive language practices, along with communication, explanation, and questioning. Students must comprehend the similarities and differences between argumentation in real life, argumentation in science, and argumentation in literacy. Informal arguments include meetings, conferences, group discussions, and classrooms; formal arguments include congress and law/court-based arguments.

4.3.1 Module Goals

(1) Lead students in crafting arguments to substantiate claims with clear reasoning and relevant evidence.

(2) Explore techniques to scaffold instruction for building scientific arguments.

(3) Facilitate collaborative and engaging discussions on debatable topics.

(4) Offer students practice locating reliable sources for both sides of an issue and adopting a stance on the matter.

In Module 3, the presented ELD and Science concepts include:

Science Concept 1: Teachers need to support students' grasp of scientific argumentation.

ELD Concept 1: To participate in argumentation, MLs require scaffolds and explanations of concepts, social and academic language, and cultural differences and attitudes necessary for productive discussions.

Science Concept 2: Teachers need to provide students with opportunities to state and substantiate scientific claims with evidence. This evidence may stem from their science investigations and informational texts.

ELD Concept 2: MLs should have access to materials in their native language or in English that are at Lexile levels appropriate for the proficiency levels in reading.

4.3.2 Activity 1

Debating offers students excellent opportunities to gain scientific argumentation skills while using language authentically. This activity centers on Earth's movement in space. Divide the class into two groups: assign one group the role of early scientists who believed the sun revolved around the Earth, and assign the second group the role of modern scientists who discovered the earlier theories were wrong and believe the Earth revolved around the sun. Have each group consider potential arguments these historical figures might have made. For instance, the early scientists who believed the sun revolved around the Earth relied on visual experiences of the sun rising in the East and setting in the West each day. Conversely, other scientists, aided by modern telescopes, took more accurate observations of stars and planets, leading to a different conclusion. Mock debates are often enjoyable as they must engage students in conducting research to gather evidence to defend their claims. This activity also highlights that scientists can be wrong when more accurate evidence is uncovered.

Potential MLs Adaptations

MLs may lack sufficient oral proficiency to engage in scientific argumentation, even after acquiring the academic terms related to the studied topic. Specific language structures must be provided, along with practice and repetition. MLs may be able to present arguments orally but not in writing, so writing needs scaffolding and support through specific language structures, offering opportunities to express their knowledge with concise language. Frontloading, explanation, and practicing academic language (e.g., argument, debate, evidence, claim) are essential to encourage student participation. Engaging in argumentation is more than mere practice; it is a cultural skill that students need to become accustomed to and familiar with. This skill involves understanding what constitutes a sound argument and how to substantiate it with evidence. Students in the high spectrum of emerging proficiency and bridging levels are likely capable of creatively using language to defend their positions.

For less proficient MLs, offering sentence starters is crucial for engaging in arguments, such as "I believe that . . . because the reading says." It is probable that those at the emerging and bridging proficiency levels can creatively use language to defend their positions. Furthermore, certain cultures tend to defer to authority and seek the middle ground between conflicting ideas, making it challenging to engage in Western-style argumentation (Nisbett, 2003). Some linguistically and culturally diverse students hesitate to participate because they lack experience critiquing others' ideas or suggesting their own. Publicly disagreeing or even agreeing with peers might be unfamiliar, and they might never have been asked to express their opinions. The implication of these cultural differences for argumentation is that MLs need to learn how to respectfully disagree, agree with others' ideas, and request evidence for their peers' claims. Introducing MLs gradually to the concept of argumentation, without pressuring them to participate until they are ready, helps keep their affective filter and anxiety levels low.

4.3.3 Activity 2

Activity 2 continued in the same direction, encouraging students to explore how scientific arguments may change when new evidence is discovered. Teachers can use news articles to showcase the fact that scientists, even now, continuously refine their knowledge based on newer evidence. For instance, teachers can assign students to read an article demonstrating newly discovered fossil evidence that humans were in North America long before previously thought. Just reading about these scientific developments fosters a more open attitude toward scientific argumentation and emphasizes the importance of supporting one's claims with evidence. Also, such discussions assist students in growing their academic language skills.

Potential ELD Adaptations

To incorporate readings at various proficiency levels, teachers may use websites like Newsela to find science articles written at different Lexile levels. This approach ensures materials are accessible to students who can grasp the main ideas and participate in conversations about the readings while finding evidence to support their claims (i.e., once the teacher has introduced and taught these concepts and demonstrated and practiced finding them in texts). For students at emerging proficiency levels, the teacher can focus on basic vocabulary in the text and provide visual aids such as pictures or gestures (e.g., bones, dirt, dig).

4.3.4 Activity 3

This final activity combines the previous two by engaging students in scientific argumentation and guiding them to formulate claims based on evidence. Teachers present the prompt "Should we keep animals in zoos?" on the board. Students then partake in one of three distinct argumentation activities: (a) Think-Pair-Share, (b) Argument Line, and (c) Four Corners.

Think-Pair-Share

(1) Pair up students.

(2) Provide the following three prompts for their scientific argumentation discussion on "Should we keep animals in zoos?"

THINK: My thoughts or understanding at this time.

PAIR: What I understand my partner is telling me is . . .

SHARE: Our common understanding after talking, what we can share with others, and what was most important from our discussion.

Argument Line

(1) Create space in the classroom for all students to stand along an "imaginary" line.

(2) Assign one end of the "line" to those who strongly believe zoos benefit society.

(3) Assign the opposite end of the "line" to those who firmly believe that animals should NOT be kept in zoos.

(4) Designate the middle of the "line" for those who recognize that both point of views could be valid.

(5) Prompt students to move to a point on the lines that most closely fits their personal belief.

(6) While students are positioned along the line, call upon different students to share their viewpoint and why.

Four Corners

Create four distinct points of view for the zoo argument, such as:

(1) Zoos are good for society because . . . or "I am pro zoos because . . ."

(2) Zoos are not good as they take animals out of their natural habitat because . . . or "I am against zoos because . . ."

(3) Both points of view are equally valid because . . .

(4) Neither point of view is valid because . . .

Assign each argument to a separate corner of the room and have students choose a corner that best reflects their viewpoint, then encourage them to discuss it with others.

*Variation: Teachers can use the Four Corners approach with different topics (e.g., the best season, or the most interesting character in a story).

Potential ELD Adaptations

For the specific activity involving supporting argumentation about animals in zoos, teachers must clarify the meaning of being "pro" or "against" and explain the concept of the argument. For example, they could annotate their presentation or poster with "Pro=For=Advantages=Positive aspects of" and "Against=Con=Disadvantages=Negative aspects of." Once students grasp the distinction between the two concepts, teachers should reinforce vocabulary usage by posing questions like "What do you consider the advantages (i.e., the good things) of zoos?" and "What do you think are the disadvantages (i.e., the bad things) of zoos?" Students would also benefit from employing sentence starters like "I believe that the advantages of zoos are" or "In my opinion, the disadvantages of zoos are."

Teachers might also simplify the argumentation activities, such as using written signs accompanied with illustrations for each corner in the Four Corners activity (e.g., "Zoos are good," "Zoos are not good," "Zoos are both good and not good"). To accommodate the linguistic needs of students at emerging proficiency stages, visual aids like animal pictures can be used to teach animal names and basic words like colors. For students at a more advanced stage, questions may require more complex responses, such as "Is it good or beneficial to keep animals in zoos?" Linguistically and culturally, students possess insights about their community's practices. Teachers should leverage their experiences (e.g., living on a farm and observing plants, animals, crops, and weather phenomena) to plan for constructing arguments and providing evidence on subjects MLs are knowledgeable about.

Other effective strategies for supporting/scaffolding argumentation for MLs include:

(1) Modeling the argumentation activities by frontloading relevant vocabulary before reading and displaying it on a chart (using illustrations if possible).

(2) Asking students to refer to the vocabulary chart during reading.

(3) Supplying students with sentence frames for articulating their positions on an issue using the corners: "I chose this corner because I believe . . ."

(4) Encouraging students to build and add new vocabulary and sentence structures to their personal dictionaries. Students may use the Frayer's model for understanding and practicing with vocabulary (Balisar Panjaitan & Sihotang, 2020)

(5) Over time, teaching students a range of synonyms to diversify their statements and responses in argumentation (e.g., "In my perspective . . ." "According to me . . ." "From my point of view . . ." "I assume . . ." "I would argue . . ." "The way I see it . . ." "I feel . . .").

5. ELD Through Science Modules Effectiveness

Participants in the workshops completed a survey at the end of each module. The surveys included Likert scale questions and at least one open-ended question. The Likert scale questions ranged from strongly disagree to strongly agree. For Years 1 and 2 combined, 100% of teachers agreed or strongly agreed with the statement, "At the end of the four workshops, I felt effective teaching science to English learners." For the statement, "The information from this workshop will help me implement the English learner Roadmap in my school district," 95% agreed or strongly agreed (i.e., combined surveys for Years 1 and 2).

The following are samples of teachers' responses to the open-ended question, "In general, what challenges and successes do you encounter when teaching science to English language learners?":

(1) "Being a Dual Immersion teacher, having students who are both English and Spanish Learners, something I see successful is the fact that I am able to pair students according to their language level. An English Only student can be of great help to an English Language when collaborating, as they are able to model conversation for the English Learner."

(2) "[One challenge] is time. My district is very focused on ELA and Math, and it is very common for students to miss science and social studies instruction due to excessive minutes being required each day for ELA and Math, but specifically ELA."

(3) "The science academic language is a challenge to our English learners. However, based on today's training, posing phenomena to our students is very engaging and gets them to produce some language. Once answers are shared, the teacher can paraphrase the students' answers and incorporate the academic content language as well as support it with visuals and TPR [total physical response]"

(4) "Since most of my students are English learners, I find that I have great success with student engagement when sentence frames are incorporated. I love using videos, realia, and literature to teach different concepts."

(5) "The vocabulary seems to be the hardest to teach. I loved the ideas shared in this webinar."

(6) "I loved, loved, loved all the scientific drawings ideas, how to teach students how to observe with purpose, use of notebooks to record observations and adaptations for EL learners. I am so excited to teach how to do observations in my classroom."

6. Conclusion

The participants' responses and interactions with presenters underscore a significant need for science workshops in elementary grades, particularly for multilingual students. Science can serve as a vehicle for teaching academic language across various proficiency levels, provided that teachers employ scaffolding techniques, demonstrate cultural responsiveness, and offer multiple means for multimodal activities and comprehensible input. As teachers realize the many opportunities to simplify science concepts and language while introducing higher-level vocabulary to their students' oral and written repertoire, they will be better equipped to offer MLs more equitable access to the curriculum. As schools address the demands of the 21st century for future citizens and workers, skills that can be developed through science, such as critical inquiry, scientific reasoning, observation, and argumentation, will play a crucial role in striving and problem-solving in an ever-changing world.

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