FOCUS BULLETIN

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Words for Science Learning: Which Words and When?

Introduction

Rosario is starting her new job as a middle school ESL specialist. After completing her ESOL certification five years ago, she taught in a self-contained ELD classroom. Her new position involves supporting students and teachers in middle school science. Rosario has not been in a science classroom for many years, and she does know that science has a lot of new vocabulary, so she decides to brush up a bit. She has lots of experience pre-teaching vocabulary, but is puzzled when the science educators with whom she will work say that they hope she will not insist on that approach.

Clearly, things have changed! Rosario no longer feels so confident. Wondering how to support her students' science learning, she meets with her two science colleagues to learn about the curriculum and associated pedagogy. They are eager to explain how their avoidance of pre-teaching vocabulary connects with the way they teach students to do science.

Science is Sensemaking

Rosario is not alone in her confusion. ESL and science educators working together often experience tension between what has previously been taught as best practice, and the way science teaching and learning have changed with the Framework for K-12 Science Education (NRC, 2012) and subsequent Next Generation Science Standards (NRC, 2013). When Rosario took science classes, she did pretty well, because the tests focused on what she was good at: remembering facts and vocabulary terms. But today, her new colleagues explained, science centers around sensemaking—a new term for Rosario, but one familiar to many science educators.

> Sensemaking *is actively trying to figure out how the world works (science) or how to design solutions to problems (engineering). Students do science and engineering through the Science and Engineering Practices (SEPs). Engaging in these practices necessitates students be part of a learning community to be able to share ideas, evaluate competing ideas, give and receive critique, and reach consensus. Whether this community of learners is made up of classmates or family members, students and adults build and refine science and engineering knowledge together. (NSTA, from the NSTA Sensemaking Website.)*

> *WIDA's* Making Science Multilingual *project developed a similar definition of sensemaking: Sensemaking is all about using the tools of science to make sense of the natural world. Students begin with the shared experience of a relevant and compelling phenomenon, and work together to learn about the core ideas of science (Disciplinary Core Ideas). They make connections (Crosscutting Concepts) beyond the phenomenon to their lives and communities and to other areas of science. Guided by the Science and Engineering Practices, they learn how to examine ideas, ask science questions, gather data, and make claims that they can support with credible evidence. By engaging with all three dimensions of science and with one another, students co-construct new understandings about the world through the lens of science.*

As Rosario learns about sensemaking, she asks, "But students still need to learn all those new words, right? How and when do they get a chance to do that?"

Why Not Emphasize Vocabulary?

Rosario's colleagues agree that students need to learn some words upfront to help them participate in classroom activity. The names of tools (e.g., beaker, scale, pipette) can be taught, as these objects are pointed to or labeled, and some actions can be demonstrated quickly (crush, float). But what about words like *oxidation* or *evaporation*?

Many science teachers are familiar with the reminder "ABC," meaning "activities before concepts" as a way to structure inquiry-based learning. This reminder to involve students in experiences with phenomena and scientific processes before naming related concepts has become increasingly relevant with the shift toward sensemaking. Lessons begin by engaging students in activity and conversation about puzzling phenomena.

The Next Generation Science Standards provide more information about doing science. See the following Appendices:

- Science and Engineering Practices: Appendix F.
- Disciplinary Core Idea Progressions: Appendix E.
- Crosscutting Concepts: Appendix G.

As students pose questions and discuss emerging ideas, they learn to do science. They use the practices of science *(asking questions, developing and using models, planning and carrying out investigations, etc.)* to understand important science content ideas *(animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4))* and, over time, connect these to bigger, overarching Crosscutting Concepts *(cause and effect; structure and function; energy and matter).*

In these early conversations, as questions and ideas are emerging, students may not know and do not need technical, precise vocabulary terms. Students can discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to communicate their ideas, (Haverly et al, 2021; Lee, Quinn & Valdés, 2013; Suarez et al, 2020; Weinburgh et al, 2021), especially when supported through the common science practice of using models such as objects or diagrams to illustrate ideas.

Translanguaging also serves an important function during sensemaking. With the focus on ideas, students can use whatever combinations of their languages they need to express and explore ideas, whereas restricting students to using only one language can slow down their sensemaking.

> ***Translanguaging*** refers to the ways in which multilingual learners access and use their full linguistic repertoires in communication and learning, including by using more than one language.

Similarly, expecting students to use technical terms can impede the flow of ideas. If technical vocabulary is introduced too early, the implied expectation that students shift to using "correct" words can slow down students' sensemaking conversations or even bring them to a halt. Richardson Bruna, Vann, and Perales Escudero (2007) showed how a 9th-grade "EL Earth Science" teacher who saw her main goal as building vocabulary inadvertently constrained learning opportunities for students learning English. Working with vocabulary alone meant that students were not engaged conceptually with the earth science knowledge at stake. The vocabulary-focused tasks tightly constrained classroom discourse, preventing students not only from talking like scientists, but also from thinking like scientists. Similarly, Bunch & Martin (2021) note that focusing too early on academic vocabulary "means that teachers might miss out on understanding what students are actually thinking" (p.3).

We all have run into situations where students were able to use the correct scientific term for a concept without any understanding of the concept. The meaning of a science concept is captured in a web of related information, not a word. Until a student can connect the word with that web of information—through experience with a phenomenon or by connecting it to similar and related words that are already known—the word itself conveys and holds relatively little meaning.

Students learning English may not yet be able to quickly connect new terms with their meaning, and the implication that they should stop using familiar vocabulary can be a roadblock to their engagement in the conversations central to scientific sensemaking and language development. Rather than introduce technical science vocabulary before a lesson, teachers introduce these terms when students have had some experience of the concept or process. As the lessons progress, they continue to use students' everyday words along with the new terms, toggling back and forth between the familiar and the new so that students have many opportunities to hear and use new words and phrases in the contexts and activities where meaning is constructed. They know that students' understanding of the concepts and the words that represent them will develop as they discuss ideas together over several days, so that, over time, the words will have meaning.

> Throughout their science education students are continually introduced to new terms, and meanings of those terms can be learned only through opportunities to use and apply them in their specific contexts (NRC, 2012, p. 95).

Just as science ideas are taught by embedding them in experience, new words are also understood through experience. This is very different from frontloading vocabulary!

Embedding Language Learning into Sensemaking

Sensemaking is a very interactive process, with many opportunities to learn and practice new language. When scientists—and students learning science—make sense of something in the natural world, they ask questions, plan investigations, interpret data, develop and revise explanations, make and revise models to show their thinking, make claims based on their evidence and reasoning, and critique one another's ideas. These important activities—included in the NGSS Science and Engineering Practices (NRC, 2013)—describe what students do as they learn science.

Continually ask the question, "When do students need to know a term, and why?" It is reasonable to expect students to know vocabulary by the end of a unit; the question is when does it serve their sense-making? (Haverly et al, 2021, p. 26)

Everyday language serves well for most of these conversations, but students soon experience the benefit of using technical terms. It is simpler and faster to say "oxidation" than it is to keep saying "that thing that happens when the air touches it," or "the diaphragm" instead of "that part under the lungs." When a concept is understood, introducing the "shorthand" term for it supports students in attaching the new word to the shared experience and the exchange of related ideas.

Similarly, students need support to learn English words and phrases to express ideas clearly, seek clarification, ask one another questions, and critique and support ideas. Helping students learn this kind of language—the language of ideas (Bunch & Martin, 2021)—is essential for supporting engagement in the sensemaking conversations crucial to doing science.

Teaching the Language of Ideas

"... the role of an ESL teacher is to identify how a strategic focus on language can support the content teacher in reaching the content learning goals with ELs." (NASEM, 2018, p.97).

Rosario now has an expanded understanding of science vocabulary, one that is far more than single words and definitions. She understands how the multilingual students she supports will be using language as they do science. She knows that, with support, they can use everyday language to enter into sensemaking. But, she also knows that learning additional ways of using language will benefit them as they write about their ideas in their science journals or on tests, and when they bring their ideas to multiple audiences and settings in school and in their communities. Where can she find resources for expanding students' effectiveness in talking about science ideas?

ESL educators like Rosario are undergoing a shift in practice similar to that of science educators, who needed support and practice as they learned to build science lessons around sensemaking. ESL educators need support in building *language* lessons around sensemaking. Since sensemaking activities center around the Science and Engineering Practices, the science and language experts in WIDA's *Making Science Multilingual* program organized a language-focused resource around those science and engineering practices, which you can find in the Closer Look beginning on page 7 of this bulletin.

The **Closer Look** shines a spotlight on the language of ideas. In this resource you can find examples of language learning opportunities embedded in the Science and Engineering Practices.

Conclusion

"Language development and concept development occur simultaneously ... and are inextricable" (NASEM, 2018, p.57).

"Language is a product of doing science, not a precursor or prerequisite for doing science and ELs need ample opportunities to do science" (NASEM, 2018, p 65).

These statements that Rosario encountered during her earlier reading make more sense to her now, and highlight the shift in English language instruction that she, with the help of her science colleagues, will learn to navigate. By working together to support students' English language development in the midst of their sensemaking activities, she and her science educator colleagues will make sure that every student has the chance to be part of the crucial conversations that will help them learn to do science.

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Additional Reading

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Lee, O., Quinn, H., & Valdés, G. (2013). Science and language for English language learners in relation to Next Generation Science Standards and with implications for Common Core State Standards for English language arts and mathematics. *Educational Researcher, 42*(4), 223–233. https://doi.org/10.3102/00131 89X13 480524

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CLOSER LOOK: Embedding Vocabulary in Instruction

Science and engineering practice	Embedding vocabulary instruction in sensemaking
Asking questions and defining problems	• When observing phenomena, invite students to share what they notice in any language by asking questions like, "What do you call this (pointing to a picture)?" and writing students' responses on the board. • Teach and model words and phrases for making observations (I see…, I notice…) and asking questions (I wonder…? Why…? How…?) in a visible space in the classroom. • Highlight terms that students use as they share observations of a phenomenon, but don't replace their terms with scientific ones. Further along in the process, they will integrate science terms into their models and explanations (e.g., parts of a volcano). • Make students' questions and ideas visible to all in writing. Writing them down often provides an opportunity to clarify words used or needed.

Developing and using models
 	
(Note: Models are tools for representing ideas and explanations, such as sketches, diagrams, objects)
	• Emphasize words and phrases for group work, such as the Student Moves in the Information Kiosk in Sensemaking Hall. (link to these)
	• When students are creating or revising models to clarify their thinking, ask questions such as
	  ◦ Do you mean sometimes or always?
	  ◦ Do you mean all of it or only this part of it?
	  ◦ Do you mean outside or inside?
	• Provide students multiple exposures to words associated with Crosscutting Concepts, like cause and effect, structure and function, system, cycle, etc.
	• Encourage students to label sketches or diagrams they create.

CLOSER LOOK: Embedding Vocabulary in Instruction

Science and engineering practice	Embedding vocabulary instruction in sensemaking
Planning and carrying out investigations	• Make sure students know the names of tools and equipment and where to find them in the classroom. • Remind students of words and phrases they can use to respond to each other's ideas. • Encourage students to use their science notebooks to write the question they are exploring and to write or draw the steps they plan to take to answer that question. Model the language needed to express the order or sequence of steps. • Provide students multiple exposures to relevant words, such as "variable" and "control" in an investigation, or the language of prediction (e.g., if we do… then…; it's likely that…; what should happen is…).

Analyzing and interpreting data	• Model words and phrases to analyze or compare and contrast patterns in data (e.g., We noticed differences/similarities in….; maximum/minimum; As _____ increases/decreases; There is a correlation between…; outlier).
	• Model words and phrases used to ask questions about data:
	    • How many…?
	    • What percentage…?
	    • How does a change in _____ affect ______?
	    • Why did you choose…(that kind of graph)?
	    • Measurement error, sources of error, relationship, range of difference, data point
	• Explicitly teach labeling conventions for data displays

CLOSER LOOK: Embedding Vocabulary in Instruction

Science and engineering practice	Embedding vocabulary instruction in sensemaking
Using mathematics and computational thinking	• Model language for talking about events that proceed in a sequence. • Model language for expressing the logic that relates ideas to one another. • Use counting and numbers or numerical data to make a prediction or solve a problem. • Emphasize words associated with Crosscutting Concepts (cause and effect, proportion, function, structure, system, cycle, flow, stable, classification) to support students in using them to communicate and refine their ideas. • Model phrases for stating initial claims based on evidence. Write examples of claims being discussed so that students begin to notice patterns in language used to express a claim. • Highlight differences between everyday terms and more specialized terms and discuss reasons why one is more effective than another for the situation. • As students begin using scientific terms, explore the meaning of words, highlighting parts of words (prefixes, suffixes) and cognates when relevant.

CLOSER LOOK: Embedding Vocabulary in Instruction

Science and engineering practice	Embedding vocabulary instruction in sensemaking
Constructing explanations and designing solutions	• Model language for comparing and evaluating claims and expressing evidence-based reasoning. • Highlight examples of recurring words and phrases used to compare and evaluate claims and express evidence-based reasoning so that students begin to notice patterns in how language is used. • When appropriate, provide students examples of ways to express their ideas with increasing precision (e.g., using scientific terms instead of more general terms, using precise numbers, clarifying relationships among ideas). • Model language for clearly expressing the degree of certainty (e.g., perhaps, possibly, could be, may be, must be, should be, certainly).
Engaging in argument from evidence	• Model language for comparing and evaluating claims and expressing evidence-based reasoning. • Highlight examples of recurring words and phrases used to compare and evaluate claims and express evidence-based reasoning so that students begin to notice patterns in how language is used. • When appropriate, provide students examples of ways to express their ideas with increasing precision (e.g., using scientific terms instead of more general terms, using precise numbers, clarifying relationships among ideas). • Model language for clearly expressing the degree of certainty (e.g., perhaps, possibly, could be, may be, must be, should be, certainly).

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CLOSER LOOK: Embedding Vocabulary in Instruction

Science and engineering practice	Embedding vocabulary instruction in sensemaking
Obtaining, evaluating, and communicating information	• Discuss with students how genres (e.g., a science textbook, a poster designed to educate the public about science) influence an author's choice of vocabulary (e.g., precise terminology and sequence of actions). • Model the use of text features (e.g., headings, tables of contents, glossaries, icons, labels on data displays and diagrams) for navigating and interpreting information in the text. • Highlight examples from texts of words that help to distinguish the author's attitude, perspective, or stance (e.g., certainty, possibility, caution, authority). Discuss with students the reasons why a certain stance is appropriate for the genre and the information conveyed. • Provide examples of words used to create cohesion in texts, especially written texts or more formal oral presentations. • When students have an opportunity to revise and edit a presentation or written product, encourage a focus on larger issues of content, organization, use of multiple modalities, and author positioning **before and in addition to** sentence structure, grammatical structure, and vocabulary.

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