Integrating Language While Teaching STEM

NCELA Teaching Practice Brief

Effective instructional practices, examples, and practice shifts for science and engineering teachers

This is the first publication in a series of briefs that are designed to highlight promising practices for educators and other staff who support English learners (ELs) and their families with English language acquisition and the maintenance of native languages.

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Introduction

This practice brief draws upon recent recommendations[1] regarding English learners (ELs) and evidence-based instructional practices for teachers relevant for learning in science and engineering in grades kindergarten through 12 (K–12). Five key educator practices are featured:

1. Embrace asset beliefs that position and support ELs as full participants in disciplinary learning.
2. Engage ELs in science and engineering practices.
3. Engage ELs in meaningful interactions with other students and teachers.
4. Provide scaffolding as a way of supporting students' engagement and comprehension of challenging content.
5. Provide an explicit focus on how language functions in these disciplines.

For each key practice, we

- describe it and reference the research evidence;
- illustrate the practice in action; and
- offer additional tools and resources.

1. Embrace asset beliefs that position and support English learners as full participants in disciplinary learning.[2]

Description of Practice

All teachers hold beliefs about ELs and about their ability to learn. These beliefs can be classified into deficit beliefs and asset beliefs. *Deficit beliefs* position ELs as unable to learn due to a lack of formal education, limited English proficiency, or some other perceived disadvantage. *Asset beliefs*, by contrast, acknowledge that ELs arrive at school with rich knowledge and skills that enable them to engage in disciplinary learning. Researchers (Cohen & Lotan, 1995, 1997, 2014; Pinnow & Chval, 2015) have found that when teachers position ELs as students with deficits, this influences their position in peer interactions and makes it difficult for them to gain access to academic debate and discussion. However, when teachers acknowledge the cultural and linguistic resources that ELs bring to the science classroom, students can envision themselves as legitimate participants in their own learning. Teachers play a key role in grouping ELs and structuring activities so that they have regular opportunities to share their ideas, hence creating the belief among all that they are competent classroom community members (Yoon, 2008).

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[1] The two documents that inform this brief are English Learners in STEM Subjects: Transforming Classrooms, Schools and Lives (2018) https://doi.org/10.17226/25182, and *Educator Toolkit: Using Educational Technology—21st Century Supports for English Learners* (2018). https://www2.ed.gov/rschstat/eval/title-iii/educational-technology-educator-toolkit.pdf

[2] The term "disciplinary learning" is defined as the learning that is expected to emerge within a specific discipline (e.g., the learning that takes place in mathematics, science, social studies, etc.).

Practice in Action

Teachers can make positive statements to communicate a belief in students' scientific abilities (e.g., "I know you have some great predictions about what will happen to the bridge in an earthquake."). Teachers can also position students as resourceful and powerful contributors to their own and others' learning by inviting ELs to share their expertise and real-life experiences, as appropriate. Connecting students' historically accumulated and culturally developed bodies of knowledge and essential skills (e.g., funds of knowledge) to the classroom is a well-researched approach to instruction (DeCapua, 2016; DeCapua & Marshall, 2015; Gonzalez, Moll, & Amanti, 2005). For example, when a teacher notices that an EL who spent the first 13 years of his or her life in South Korea is silent in botany class, the teacher can ask the student about life in his or her country: "Dae, what kind of climate do you have in South Korea? What kinds of plants grow there?" When the teacher encourages this dialogue, over time, native English-only speaking students will recognize the contributions their EL peers make in class and will engage them in peer-to-peer discussions, thus providing more opportunities for ELs to feel that they are a part of the learning community.

Tools and Resources

For additional information on incorporating EL students' background knowledge, commonly referred to as "funds of knowledge," see the following list of resources:

Professional Reading

Bennett (2017). "ELL Students' Background Knowledge as an Academic Fund" is available at https://www.thoughtco.com/ell-students-funds-of-knowledge-4011987.

Learning about Students' Families

A tool that teachers can use to learn about their students' families is available at http://modules.nceln.fpg.unc.edu/sites/modules.nceln.fpg.unc.edu/files/foundations/handouts/Mod%204%20Funds%20of%20knowledge.pdf.

Video

A video featuring Dr. Luis Moll as he explains funds of knowledge is available at https://eclkc.ohs.acf.hhs.gov/video/funds-knowledge-video.

2. Engage English learners in science and engineering practices.

Description of Practice

Engaging ELs in science and engineering practices[3] is a major shift in contemporary views of science learning (National Academy of Sciences, Engineering, and Medicine, 2018). It entails providing students with opportunities to actively participate in tasks routinely engaged in by science and engineering experts. These practices include:

- asking questions and defining problems;
- developing and using models;
- planning and carrying out investigations;
- analyzing and interpreting data;
- using mathematics and computational thinking;
- constructing explanations and designing solutions;
- engaging in argument from evidence; and
- obtaining, evaluating, and communicating information.

A Framework for K–12 Science Education (National Research Council, 2012, p. 283) speaks to the practice of asking questions: "Students learn science in large part through their active involvement in the practices of science. A classroom environment that provides opportunities for students to participate in scientific and engineering practices engages them in tasks that require social interaction, the use of scientific discourse (that leverages community discourse when possible), and the application of scientific representations and tools. Science and engineering practices can actually serve as productive entry points for students from diverse communities—including students from different social and linguistic traditions, particularly second-language learners."

Practice in Action

Asking questions is one of many scientific practices in which scientists engage. Exposing ELs to the scientific practice of asking questions goes hand in hand with developing students' knowledge of how language is used in the discipline. In her high school physical science lesson for newcomers, teacher Tanya Warren works with students on the practice of asking questions by having them watch a video simulation of an atomic structure as it moves through space, then directs the students to ask and record their questions. Working in pairs, students practice using language to ask questions about the phenomena they see. Even with their language proficiency still developing, students begin to formulate questions as in the following exchange between two ELs (Heritage, Walqui, & Linquanti, 2015):

[3] Science and engineering practices are those activities that develop a students' understanding of how knowledge and accumulated facts are established. Science practices are the ways of "doing" science. Likewise, engineering practices are the ways of "doing" engineering (National Research Council, 2012).

Teacher: I want you to think of questions that you have about the simulation.

Student 1: For me is the question “because the the sh- the size is different.”
(silence between S1 and S2)
Student 2: The size color is ... different.
Student 1: The size and color?
(pause)
Student 1: What is your question? Other, other question.

Student 2: Wait. It’s not a question because you have “because.” It’s “WHY.”

Student 1: Ah “why!”

Student 1: “Why! Why did … Why the size and color is different?” for me is my question.

While this question is not one that can be answered in a scientific experiment, its formulation is an important step toward the development of a key scientific practice. Over time, the questions students pose will become more sophisticated and precise.

Tools and Resources

List of Science Practices:

Links to science and engineering practices with grade-level performance expectations from the National Science Teachers Association is available at https://ngss.nsta.org/PracticesFull.aspx.

Teacher-friendly Resources:

Definitions and examples of various science practices is available at http://www.sciencepracticesleadership.com/uploads/1/6/8/7/1687518/8_practices_v4.pdf.

3. Engage English learners in meaningful interactions with other students and teachers.

Description of Practice

Language and content are inextricably related. While engaging in science practices like planning and carrying out investigations and analyzing and interpreting data, students learn new patterns of language and expression. Yet, students cannot be expected to engage in science and engineering practices without support, and it is up to the teacher to create opportunities for students to participate successfully. Working in groups is one way in which students can engage in knowledge construction and language practices that are specific to science learning (National Academies of Sciences, Engineering, and Medicine, 2018). The following excerpt describes the advantages of this technique: "Well-designed and well-run group work offers many affordances for language learning and has important advantages for second language development. Learners have more chances to interact with other speakers, and therefore the amount of language they use is also increased. They tend to take more turns, and in the absence of the teacher have more responsibility for clarifying their own meanings; it is the learners themselves who are doing the language learning work" (Gibbons, 2015, pp. 49–50). In planning lessons, teachers could consider how to engage students in productive scientific discourse and interactions with others.

Practice in Action

In her 2015 book, *Scaffolding Language, Scaffolding Learning*, Pauline Gibbons describes one way that a group task could be organized so that students are required to talk. In her words, "Tasks that require talk often involve some kind of information gap—that is, a situation whereby different members within a group, or individuals in a pair, hold different or incomplete information, so that the only way that the task can be completed is for this information to be shared" (p. 56). One way to do this is to organize students into groups.

For example, in a lesson about insects, a teacher could allow groups of students to each select a particular insect to research. Each group would be required to consult one or more sources (books, websites, magazines, etc.) to collect information under certain agreed-upon headings (such as description, habitat, food, life cycle, and interesting facts). After each group has become an expert on one particular insect, the students form new groups—made up of one student who studied a different insect—and they are asked to share their information with each other. Each individual becomes an expert in the new group and has the responsibility of sharing what he or she knows. As the non-experts listen, they quietly take notes. Students now have a body of knowledge that they can draw from in a writing task.

Tools and Resources from the National Science Foundation

Teacher-friendly Resources:
For suggestions on how to encourage students to learn science by talking to each other, see http://stemteachingtools.org/brief/6.

To learn how to guide classroom conversations to support students' science learning, see http://stemteachingtools.org/brief/48.

4. Provide scaffolding as a way of supporting students' engagement and comprehension of challenging content.

Description of Practice

"Scaffolding" is a common term in education that can be interpreted in different ways. One definition comes from Walqui and van Lier (2010) who view scaffolding as temporary support provided to ELs with the goal of developing students' autonomy. There are two kinds of scaffolding—scaffolding that is done deliberately or planned in advance and scaffolding that is done "in the moment." An example of the former is when teachers provide students with carefully planned opportunities to create quality time for them to interact. This type of scaffolding is apparent in the way that learning activities are structured—for example, giving students time to think and write down their responses before asking them to share their answer with their peers (think-write-pair-share). Providing students with time to think and write may not be something a teacher will do indefinitely, but it is one of many practices (see Tools and Resources for additional examples) that can be used until students develop the linguistic fluency and confidence to respond to oral prompts spontaneously.

The second type of scaffolding is unplanned because the teacher does not know what a student is going to say or do in advance. The immediate feedback that is provided by the teacher can help the student self-correct in order to arrive at the correct answer or successfully complete a task. For more scaffolding examples, see Tools and Resources on the following page.

Practice in Action

The following activity exemplifies both types of scaffolding in action. A "sort-and-label" activity involves asking a small group of students to take a set of pictures, words, or short texts and sort them into naturally occurring categories. The activity is a form of planned scaffolding as it is a structure previously introduced by the teacher to engage students in talking about science content. In walking around the room, the teacher notices that one group is having a particularly hard time deciding whether a penguin belongs in the bird category or in the amphibian category. After watching the group struggle to reach an agreement, the teacher gently intervenes, asking pointed questions that allow students to tap into their knowledge. In this case, the teacher is providing scaffolding in the moment. She is tailoring her line of questioning in order to help students reach a defensible conclusion.

Tools and Resources

Teacher-friendly Resource:

More scaffolding ideas in science and other subjects are available at https://www.empoweringells.com/scaffolding-instruction/.

Professional Reading:

To learn about supporting science and language learning among English learners, see https://ell.stanford.edu/sites/default/files/pdf/academic-papers/03-Quinn%20Lee%20Valdes%20Language%20and%20Opportunities%20in%20Science%20FINAL.pdf.

5. Provide an explicit focus on how language functions in the discipline.

Description of Practice

Teachers of science in all grades are responsible for teaching science content, in addition to providing students with opportunities to improve their understanding of how language works in science. Many elementary teachers naturally see this as their responsibility as young students are still acquiring various features of their home language. This is not necessarily the case in middle and high school. In fact, the culture of secondary schools positions teachers as "disciplinary experts, leading them in many cases to resist taking on instructional responsibility for issues such as language development that may seem to fall outside of their disciplinary mandate" (National Academies of Sciences, Engineering, and Medicine, 2018, p. 122). However, no one is in a better position to introduce students to the language of science than the very practitioners who teach science.

Little attention has been paid to preparing science teachers to treat language as an integral part of science instead of as an ancillary feature. Many teachers, for example, mistakenly focus on preteaching vocabulary at the expense of teaching how the language of science *works*—that is, how it is structured, organized, and used to make meaning. Richardson Bruna, Vann, and Perales Escudero (2007) showed, for example, how the teacher of a ninth-grade science course for ELs focused on building vocabulary at the expense of engaging students in science concepts. By simplifying the language, one is inadvertently simplifying the science and stripping it of its core. Teaching science and language in an integrated way can be accomplished through several means—by drawing students' attention to the patterns present in language and how language is used in various scientific practices, and by helping them to recognize linguistic choices they can make in different contexts.

Practice in Action

A teacher reads a picture book, *Grand Canyon* (Chin, 2017), aloud to a group of elementary students. The book focuses on the geological features of the layers of rock which, over billions of years, have eroded to form the Grand Canyon. The pages are filled with facts and figures that describe various aspects of the Grand Canyon. Though the book resembles a story book, it is actually an informational text. This is a good opportunity for the teacher to introduce or build upon student's notions of informational texts and how they differ from picture books. After reading the book aloud, the teacher can ask students to discuss the following question with their partner in a think-pair-share format.

- Is this a story that is made up, or is this book about something that is real? Why do you think so?

The teacher can ask students to share their partners' answers. The teacher can write down the students' comments on a T-chart with the headings "Reasons I think this is a made-up story" and "Reasons I think this is a book about something real" (or something similar). Throughout the course of the discussion, the teacher can define fictional texts as made-up stories about people or places that are not real. He or she can also define nonfiction and informational texts about things that are real or that have occurred. Grand Canyon *is a book about a huge canyon that has formed over the course of billions of years in a certain part of the United States. It really exists!* Maps can be a feature of nonfiction/informational texts, so the teacher can point out that the book includes a map that shows where the Grand Canyon is located.

Diagrams are another feature of nonfiction/informational text—especially in science. A teacher can point to labeled diagrams in the margins of the pages that provide the reader with more information about the main topic. Finally, the teacher can point to the kind of language that is used in nonfiction/informational texts. The teacher can explain that the tone of the text is somewhat distant because its purpose is to provide factual information rather than to provoke emotion. There is no "once upon a time" and no mention of characters' feelings. In fact, most informational texts do not include characters at all. Subsequent lessons can expose students to other nonfiction texts in science, and the teacher and students can make a poster of what all of the texts have in common.

Tools and Resources

Lesson Planning — Best Practices:

Reflect upon the scientific practices in which you engage your ELs and think about how you can support their use of disciplinary language. Consider the following questions before, during, and after your lesson.

Before the lesson:

- What scientific concept is the focus of instruction?
- What is the science practice in which you are asking students to engage?
- What activity can you provide during the lesson to engage students in that particular science practice?
- How are you asking students to use language as they engage in the science practice?

During the lesson:

- Are students engaging in the science practice in the way that you had envisioned?
- Does the activity engage students in the use of disciplinary language? If not, why?

After the lesson:

- How effective was the lesson in engaging students in the disciplinary practice?
- What additional support may students need in order to engage in the use of disciplinary language?

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