Improving Literacy Through Science

An Argument for a Balanced Approach for All Students, Including English Learners
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Thinking, reading, and writing are authentic and natural parts of doing science. Approaching core subjects from this perspective is at the heart of disciplinary literacy. Now more than ever, it has become vital that science educators instill literacy skills grounded in real-world phenomena and applications, empowering students who are ready for the future, and ready to transform it.

Content-area reading uses generic reading strategies, regardless of the text that is being read. But disciplinary literacy is a way of approaching text with the reading strategies employed by experts in a given field — experts have specialized ways of thinking, talking, and writing. Scientists employ analytical skills to parse the validity of data in research reports, finding logical links between various findings before formulating their hypotheses.

These experts don't just rely on one resource. Their expertise is contingent on their own observations, along with the perspectives of others, expressed across several media types. Likewise, the days of using a single textbook as a teaching resource are over. Educators must begin using new types of resources in the classroom, including digital content and media to immerse students in real-world reading, writing and thinking.

Why Literacy Matters in Science

The importance of teaching students to read informational texts, use textual evidence to support their thinking, and write in a variety of domains has become standard literacy practice across all classrooms. Science content and images are exciting for students and are often a great way to excite and motivate them to engage with tasks that deepen and hone their literacy skills.

The National Academy of Sciences held a workshop in 2014 to explore the intersections between the Common Core for English/Language Arts (ELA) Standards and the NGSS. Contributors agreed that both sets of standards require students to:

- Attend to evidence with precision and detail.
- Gather, synthesize, and corroborate complex information.
- Make and assess arguments orally and in writing.
- Make accounts of events and ideas.
- Integrate, translate, and evaluate prose, graphs, charts, and formulas (National Research Council, 2014).

Contributors also agreed that oral and written language are two of the primary vehicles by which students gain knowledge in the science classroom. They identified the following themes related to the importance of literacy in science education:

- Reading, writing, and speaking are important to the sense making process in the science classroom.
- Science reading, writing, and speaking are uniquely complex, explicit, and precise, requiring students to use specific receptive and productive language skills.
- Science texts have unique and challenging words, grammar, patterns, and representations.
- Science teachers have an important role to help students gain disciplinary literacy.
- Students need time to grapple with challenging text and concepts in order to derive meaning.

The teaching of science provides multiple opportunities for students to read, think, and write like scientists. In addition, as many teachers report, that having students engage in oral and written discourse in science supports their development of reading skills.

“Doing Science”

The Framework for K-12 Science Education (NRC, 2012) represents a vision of science and engineering education that encapsulates current understandings of teaching and learning. Informed by decades of research, the Framework defined and expanded scientific literacy. The Next Generation Science Standards (NGSS; NGSS Lead States, 2013) reflect the conceptual shifts of the Framework and intend to move science education toward this vision of students thinking and acting like scientists and engineers who use many different tools and ways of thinking to explain phenomena and solve problems. For science and engineering, this means that students still need focused sensemaking and problem-solving opportunities that allow them to deeply build an understanding of fundamental science and engineering ideas, practices, and ways of thinking, as well as discipline specific forms of literacy (NAP, 2020).

The Framework and the NGSS built on previous standards and research on student learning. Most K-8 students had a limited understanding that science is the process of theory building, modeling, and testing (NRC, 2007). The NGSS, written as three-dimensional learning statements, combine the dimensions of science and engineering practices (SEP), disciplinary core ideas (DCI), and crosscutting concepts (CCC) in order to better reflect the real-world work of scientists and engineers (NGSS). For example, scientists will investigate an environmental phenomenon, analyze data from the investigation (SEP), and develop a model to describe the system (CCC), then communicate their ideas (SEP) for how human activities have affected the land. While engineers will design a new method (SEP) to monitor human impacts (CCC) on the environment (DCI).

Previous standards separated “process skills” from the science “content” with a tendency for curriculums to have “meaningless procedures” devoid of significance and context. Also, standards often contained too many scientific ideas, many of which were disconnected. Written and oral discourse in the classroom is essential to science learning. With guidance, students can explain their ideas and understand that explanation is the goal of science, rather than repetition of facts (NRC, 2007). The Framework outlines how fewer core ideas could provide more instructional time for discourse and classroom discussion, leading to deeper understanding of content as students build connections between scientific concepts (NRC, 2012). The Framework and the NGSS challenge curriculum developers to design units with lessons that integrate the three dimensions of SEP, DCI, and CCC and ensure coherence across their defined scope (e.g., unit, grade, grade band).

What Does “Reading About” Science Mean?

Science inquiry that integrates with reading has positive effects on motivating students to want to read more. Students showed gains in both reading comprehension of science texts and on standardized tests in science (Guthrie, 2004).

Any education in science and engineering needs to develop students’ ability to read and produce domain specific text.

As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering (NRC, 2012). When students read domain-specific text, including books, articles, and media text, students should find meaning in the text.

Text-centric curricula are criticized when the text supplants science inquiry. Science and literacy educators agree that text-only science is weak science instruction. Since scientists regularly use text-based tools such as reading and writing, along with symbol and graphic representations, replicating scientific practices of obtaining and communicating information and modeling in the classroom is genuine to what scientists do (Pearson, 2010). Therefore, reading, writing, and representing continue to be critical to learning science when balanced with science inquiry. From a teacher’s perspective, students engage in sense making of a 2 phenomenon when presented with a nonlinguistic mode of communication such as a model that describes how genetic mutations affect an organism’s traits before students read a text about the topic or viewing a video showing the systems in an air conditioner paired with text explaining how they function. Further, when students are challenged to ask questions or identify problems about the phenomenon, they begin to develop a mental framework. Reading text fills the emerging mental framework and leads to revision of the framework. This deeper understanding of the phenomenon informs the students’ understandings of other texts, motivates reading for information, and contextualizes assessment questions. Practically, a text heavy science curriculum leaves little room for the engagement and sense building that inquiry science provides.

Reading domain-specific text plays an important role to support students’ science learning when texts are coherent and relevant and when texts provide support for inquiry (NRC, 2007). The Framework designates the SEP of obtaining, evaluating, and communicating information and the NGSS further define the elements of the practice [e.g., 6-8 Critically read scientific text adapted for classroom use to determine the central ideas and/or obtain scientific and/ or technical information to describe patterns in and/or evidence about the natural and designed world(s)]. Clearly, the SEP of obtaining information plays a role along with other science and engineering practices, recognizing the fundamental role of reading and producing scientific text (NGSS, 2013). Classroom teachers observe that students’ engagement increases and students’ understandings of scientific content deepen when linguistic and nonlinguistic modes of communication are incorporated throughout classroom instruction.

How Do “Doing” Science and “Reading About” Science Impact English Language Learners?

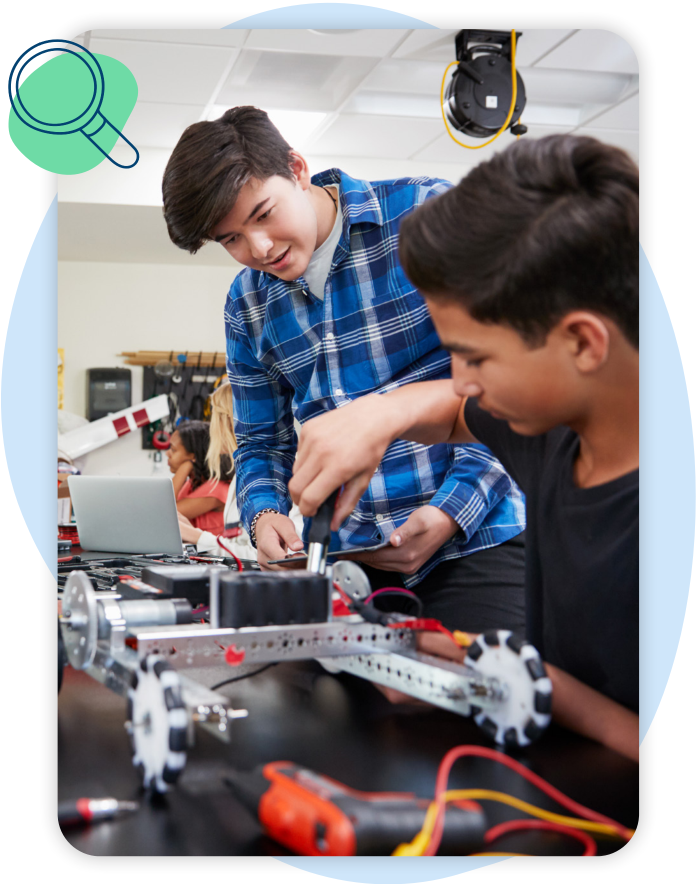
A confluence of factors generally impacts English Language Learners (ELLs) in STEM subjects and specifically in science.

For English Language Learners “doing” science has a twofold affordance. When ELLs participate in the classroom scientific community, they use language in a purposeful way. When units are designed with three-dimensionality, ELLs can engage with their peers in meaningful rigorous science learning, regardless of their English proficiency level. Classrooms and curriculums can make opportunities for meaning-making when ELLs can shift registers (informal to domain specific) and use multiple linguistic (talk and text) and nonlinguistic (e.g., graph, symbol, equations, gesture) modalities (National Academy Press [NAP], 2018) (Lee, 2019). Multimodal representations (e.g., textual, symbolic, and visual representation) may lessen some linguistic hurdles in content and test items (NAP, 2018).

Access to “doing” science includes “newcomers” who grow in English with peer interactions as they use language while doing science (Solano-Flores, 2008). A meta-analysis comparing the effects of inquiry instruction to science achievement in grades 1-6 confirmed that inquiry, “doing science,” has greater positive impacts on all students, including ELLs, than traditional, content-heavy, direct science instruction (Estrella 2018). Access to rigorous STEM content is important for achievement, however, not all educational experiences are equal and ELLs may not always have access to rigorous content (NAP, 2018). When the language of instruction is exclusively English, some ELLs do not have opportunities for learning and are disadvantaged compared to their English-speaking peers (NAP, 2018) even though most have formal knowledge in science gained from schooling in their original country.

The National Academies conclude: With appropriate curricular and instructional support, English Language Learners can participate, contribute, and succeed (NAP 2018) as they engage in sensemaking and problemsolving opportunities that allow them to deeply build an understanding of fundamental science and engineering ideas, practices, and ways of thinking, as well as discipline specific forms of literacy (NAP, 2020).

The need for focused sensemaking is equally important to all students, including English Language Learners. Specialists generally agree that the linguistic demands of processing science content in text can disrupt reading comprehension for all students (Snow 2010, Patterson 2018). Therefore, a science curriculum that relies on a balance between “doing science” and “reading about science” in text provides opportunities for all students, including ELLs, to achieve.



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Improving Literacy & Accessibility for All with Discovery Education

Teaching science and literacy together provides multiple opportunities for all students to read, think, and write like scientists in ways that can improve their performance in both disciplines. With the variety of content types and learning supports like those found in Discovery Education *Science Techbook*, students not only build their content knowledge, but they also develop and strengthen their literacy skills through robust resources and lessons that use research-based instructional reading, writing, speaking, and listening strategies.

Science Techbook is a dynamic and adaptable digital first curriculum solution that sparks curiosity and drives active investigation of real-world phenomena. Exclusive and original multimedia content engages students in authentic three-dimensional learning and solution seeking opportunities—making science accessible and 3 relevant. Intentional sequencing of activities through the storyline framework prompts students to ask questions, build models, and develop scientific explanations to generate evidence of their sensemaking—building and strengthening their literacy skills.

Science Techbook also provides embedded supports for students like highlighting and text annotating to decipher content-rich texts, as well as an interactive glossary that utilizes not only the definition of a word, but also a video, an animation and an image. Search features offer both teachers and students access to an extensive array of leveled resources, giving them the freedom to choose content that best suits their learning needs or interests. Teachers can assign content and tasks matched to individual students or groups, and language and display options allow students to adjust readability and language preferences, helping to make learning accessible for all students and improving fluency and literacy at all levels.

Sources

1. Estrella, G., Au, J., Jaeggi, S.M., and Collins, P. (2018). Is inquiry science instruction effective for English language learners? A meta-analytic review. AERA Open, 4(2), 1–23.

2. Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., David, M. H., Scafiddi, N. T., & Tonks, S. (2004). Increasing reading comprehension and engagement through Concept-oriented Reading Instruction. Journal of Educational Psychology, 96(3), 403-423.

3. Lee O, Llosa L, Grapin S, Haas A, Goggins M. Science and language integration with English learners: A conceptual framework guiding instructional materials development Science Education. 2019;103:317–337.

4. Magnusson, S.J., Palincsar, A.S., Lomangino, A., Hapgood, S., How Should Learning Be Structured in Inquiry-based Science Instruction?: Investigating the Interplay of 1st- and 2nd-hand Investigations April 2004 Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA; Session 65.023: Reading, Writing, and Understanding Science.

5. National Academies of Sciences, Engineering, and Medicine 2018. English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives. Washington, DC: The National Academies Press.

6. National Academies of Sciences, Engineering, and Medicine 2020. Teaching K-12 Science and Engineering During a Crisis. Washington, DC: The National Academies Press.

7. National Research Council. (2014). Literacy for Science: Exploring the Intersection of the Next Generation Science Standards and Common Core for ELA Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

8. National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

9. National Research Council 2007. Taking Science to School: Learning and Teaching Science in Grades K-8. Washington, DC: The National Academies Press.

10. NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

11. Patterson, A., Roman, D., Friend, M., Osborne, J., & Donovan, B. (2018). Reading for meaning: The foundational knowledge every teacher of science should have. International Journal of Science Education, 40(3), 291-307. https://doi.org/10.1080/09500693.2017.1416205

12. Pearson, P.D., Moje, E., Greenleaf, C., Literacy and Science: Each in the Service of the Other

13. P. David Pearson, Elizabeth Moje, Cynthia Greenleaf. Science 23 Apr 2010: Vol. 328, Issue 5977, pp. 459-463

14. Snow, C. (2010). Academic language and the challenge of reading and learning about science. Science, 328(5977), 450–452.

15. Solano-Flores, G. (2008). Who is given tests in what language by whom, when, and where? The need for probabilistic views of language in the testing of English language learners. Educational Researcher, 37(4), 189–199.

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