

Science in Your Stacks

Using Trade Books and Literacy Strategies to Enhance 5E Science Lessons

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Many of the inquiry-based lessons and units used in middle school science classrooms follow the 5E instructional model. This model structures students' scientific inquiry across five phases: engage, explore, explain, elaborate, and evaluate (Bybee 2014). Each phase has distinct teacher and student roles that facilitate the progressive evolution of students' scientific ideas and practices.

We have uncovered parallel trade book features that align with the purpose of each phase of the 5E instructional model. These features can help you decide in which 5E phase to use your favorite trade books. We have also identified literacy strategies that enhance the inquiry focus of each phase. These strategies can help you decide how to use self-selected trade books in your own science lessons. Figure 1 shows how each phase of the 5E model aligns with these trade book features and literacy strategies.

Trade book features aligned to 5E instructional model

Questions and problems lie at the heart of every scientific investigation and engineering challenge (NGSS Lead States 2013). Students need both repeated exposure to scientific questions and engineering problems and repeated opportunities to construct these themselves. Trade books often provide more authentic and engaging ways than traditional textbooks to captivate students with such questions and problems (Houtz 2011).

Selecting which book to use and deciding on which way to integrate that book in a lesson can be arduous (Rice 2002). Use the right book in the wrong place in a science lesson and you can prematurely shut down discussions, rob students of the chance to make sense of their own observations, or reinforce common misconceptions. Although choosing appropriate trade books can be difficult, NSTA and the AAAS have experts that review hundreds of books yearly and publish their recommendations as the Outstanding Science Trade Books for Students K–12 list and AAAS/Subaru Prize for Excellence in Science Books, respectively (see Resources).

Engage

Engage activities are related to the science content included in state or national standards but do not explicitly teach the content or related academic vocabulary. Rather, engage activities capture students' attention, stimulate thinking, help students activate prior knowledge, and expose misconceptions (Bybee 2014). During the engage phase, teachers use driving questions and anchoring events to pique students' curiosity about what they will investigate during the lesson (Singer, Marx, and Krajcik 2000).

Although most anchoring events use demonstrations, models, or videos to introduce scientific phenomena, trade books can also be effective tools for achieving the same instructional goals by introducing questions and posing problems. Picture books can be particularly useful for supporting English learners during this phase as pictures create a visual bridge linking students' resources and prior experience with new

learning (Echevarria, Vogt, and Short 2004). Books with strong narrative hooks—rich, intriguing opening lines or stanzas—can also be useful in drawing out students' initial ideas about a scientific concept.

Short poems and riddles may also be used at the beginning of a lesson to inspire wonder and set the stage for scientific discovery. Riddles introduce statements, puzzles, and questions that require thoughtful solutions or answers. Both genres of text can be a fun and constructive way to focus students' attention and activate prior knowledge. Literacy strategies that work well in the engage phase include: picture preview, book talk, first line, read aloud, think aloud, and riddles and poems (see Figure 2).

Because many of the literacy strategies that enhance the engage phase of a lesson use only a portion of a book, teachers can use trade books with slight scientific errors to initiate student thinking. However, sections with errors should either be excluded from learning activities or overtly addressed at some point during the lesson.

Teachers should exercise caution when picking informational and nonfiction books for use in this phase. Engage activities should not include texts that directly teach concepts that students will discover



and discuss in the explore phase and explain phase of the lesson. It is important to preserve students' curiosity and puzzlement at this point in the lesson (Bybee 2014). In addition, avoid books that introduce an extensive amount of new academic vocabulary as these can stifle students' initial ability to connect their prior experiences to their present learning (Graves, August, and Mancilla-Martinez 2013). By focusing on books that use familiar rather than new vocabulary at this phase, teachers can formatively assess students' prior learning and identify any significant gaps in academic language development.

Explore

The explore phase gives students an opportunity to participate in hands-on inquiry through science investigations and lab experiences. As students investigate natural phenomena, they construct models, collect and analyze data, and observe patterns, as well as make, test and revise predictions (Bybee 2014).

Trade books that support synchronized reading and hands-on observations or that provide clear instructions and/or safety tips for science experiments and activities are appropriate for use during the explore phase. Interactive read alouds, including paus-

FIGURE 1: Trade book features and literacy strategies aligned to the 5E instructional model.

	5E phase summary [Bybee 2014]	Trade book features	Literacy strategies
Engage	Brief activity related to the content or practices included in the lesson objective that captures students' interest and draws out prior knowledge	<ul style="list-style-type: none"> • Launches a story of scientific discovery • Introduces a problem, question, or event • Presents a captivating picture, riddle, or poem that sparks discussion 	<ul style="list-style-type: none"> • Picture preview • Book talk • First line • Read aloud • Think aloud • Poems and riddles
Common Mistake: Using books to preteach too much material			
Explore	Concrete, inquiry experiences that provide time for students to investigate phenomena, observe patterns, formulate explanations, and clarify understanding	<ul style="list-style-type: none"> • Structures opportunities for parallel reading and hands-on activity • Provides clear instructions for science experiments and activities, including safety tips 	<ul style="list-style-type: none"> • Interactive read aloud—pause at predetermined points and complete a hands-on activity [repeat]
Common Mistake: Using books in place of inquiry investigations			
Explain	Synthesis of students' explanations and experiences with direct instruction of key scientific or technological concepts and academic vocabulary	<ul style="list-style-type: none"> • Describes or explains a scientific concept • Uses academic vocabulary and contains accurate illustrations • Supports interpretation of observations, as with field guides • Typically nonfiction 	<ul style="list-style-type: none"> • Expository text with graphic organizers • Interactive read aloud—pause at predetermined points and discuss key concepts related to explore [repeat]
Common Mistake: Using books to replace student explanations			

[continued]

es for parallel investigation, work well (see Figure 2). In synchronized reading, a section of the book is first read aloud. Then students conduct an investigation prompted by that reading. After this investigation a second section of the book is read, followed by another investigation, and so on.

Teachers should exercise caution when selecting books for use in the explore phase. Explore activities are designed to provide students with inquiry experiences that they can access later in the 5E instructional sequence. Books, or sections of books, that directly teach science content or replace student inquiry investigations should be avoided.

Explain

In the explain phase, teachers use questions to guide students through an analysis of their explore experience to construct, clarify, and modify student understanding. In addition, teachers build on student explanations and experience by explicitly teaching

scientific or technological concepts as well as academic vocabulary (Bybee 2014). This is a great time for teachers to clear up any persistent student misconceptions that may be related to the science concept being studied.



FIGURE 1: Trade book features and literacy strategies aligned to the 5E instructional model.

	5E phase summary [Bybee 2014]	Trade book features	Literacy strategies
Elaborate	Learning experiences that extend, expand, and enrich the concepts and practices developed in the prior phases and facilitate transfer to related, but new, real-world situations	<ul style="list-style-type: none"> • Applies a scientific concept in a real-world setting • Presents a challenge requiring students to apply a scientific concept or ability. • Typically biographies 	<ul style="list-style-type: none"> • Claim, evidence, and reasoning statements • Open mind portraits • Readers theater • Poetry
Common Mistake: Books used to review but not enrich learning			
Evaluate	Assessment of student knowledge of science concepts and practices included in the lesson objective	<ul style="list-style-type: none"> • Contains errors, misconceptions, or exaggerations in the text or illustrations • Reviews patterns across a scientific concept • Includes breaks between the questions posed in the text and the answers provided 	<ul style="list-style-type: none"> • Students identify and correct errors or exaggerations in the text and/or illustrations • Two truths and a lie. • Interactive read aloud—pause at predetermined points and have students complete an idea, answer questions, or make predictions [repeat]
Common Mistake: Never using books for assessment			

FIGURE 2: Literacy strategy examples aligned to the 5E instructional model and the NGSS.

5E phase	Literacy strategy	Trade book example
Engage	Picture preview	<i>The Street Beneath my Feet</i> , by Charlotte Guillain and Yuval Zommer, is designed as a fold-out, concertina journal that extends approximately 8 feet. The illustrations in this unusual book provide a visual introduction to the concept that Earth’s history can be organized and understood by careful interpretation of the rock strata beneath our feet. [MS-ESS1-4]
	Book talk	<i>My Place in Space</i> , by Robin and Sally Hirst, is a delightful introduction to the position of Earth in our solar system, the Milky Way galaxy, and the universe. [MS-ESS1-2]
	First line	<i>Water Dance</i> , by Thomas Locker, is a beautifully illustrated review of the global movement of water and how it changes state as it moves through the water cycle. The last stanza “I am one thing. I am many things. I am water. This is my dance through our world” could be used to launch a water cycle lesson or review. [MS-ESS2-4]
	Read aloud	<i>Solving the Puzzle Under the Sea: Marie Tharp Maps the Ocean Floor</i> , by Robert Burleigh and Raul Colon, is an illustrated biography that explains how Marie Tharp created the first multi-dimensional scientific map of the Atlantic Ocean floor. [MS-ESS2-3]
	Think aloud	<i>Seeds Move!</i> by Robin Page, provides opportunities for students to consider specialized features of seeds that depend on structure or animal behavior to help plants reproduce. [MS-LS1-4]
	Poems and riddles	<i>Pass the Energy Please</i> , by Barbara Shaw McKinney, is a rhyming story about the flow of energy in food chains. The beginning stanza “Food manufacturing starts with a seed, and energy awaits in a plant to be freed, Like an engine that powers the rest of the train, a plant’s the first link in an energy chain” introduces the role of plants [producers] in food chains and provides a creative way to tap into what the students know or think they know about the flow of energy in chemical processes and everyday life. [MS-LS2-2]
Explore	Interactive read alouds [pause for parallel investigation]	<i>Hatchet</i> , by Gary Paulson, includes a story line that describes how light bends when traveling through water. After seeing fish in a clear mountain lake, Brian, the main character, attempts to spear the fish with a homemade spear. He misses multiple times before he realizes that he needs to adjust his aim due to the refraction [bending] of light as it moves through water. Students can conduct a parallel investigation to explore how different mediums, including water, refract light. [MS-PS4-2]
Explain	Interactive read alouds [pause for questions & discussion]	<i>Krakatoa: The Day the World Exploded, August 27, 1883</i> , by Simon Winchester, includes detailed firsthand descriptions of the volcanic eruptions that destroyed the island of Krakatoa and hurled clouds of gas, pumice, fire, and smoke 24 miles into the atmosphere. The explosion “was the greatest detonation, the loudest sound, the most devastating volcanic event in modern recorded history” [p. 4]. The author skillfully weaves together a storyline loaded with historical details that add context to lessons about the impact natural hazards have on humans, communities, and the Earth. [MS-ESS3-2]

(continued)

FIGURE 2: Literacy strategy examples aligned to the 5E instructional model and the NGSS.

5E phase	Literacy strategy	Trade book example
Explain	Expository text with graphic organizers	<i>What If There Were No Gray Wolves? A Book About The Temperate Forest Ecosystem</i> , by Suzanne Slade, examines how disruptions in a single component of an ecosystem can lead to shifts in all its populations. Students could track the ecosystem changes with a flow map or a cause-and-effect graphic organizer. [MS-LS2-4]
Elaborate	Claim, evidence, & reasoning statements	<i>The Girl Who Drew Butterflies: How Maria Merian's Art Changed Science</i> , by Joyce Sidman, tells the true story of a 17th-century German girl who used carefully collected data to challenge long-held beliefs about insects. Maria supported her claims with evidence gathered through careful observation and detailed drawings. [Science and Engineering Practices: Constructing Explanations and Designing Solutions]
	Open mind portraits	<i>A Modest Genius: The Story of Darwin's Life and How His Ideas Changed Everything</i> , by Hanne Strager, uses clear and concise language to explain Darwin's ideas. This engaging biography includes descriptions of Darwin's early life, travels, and the fundamental ideas that framed his beliefs about natural selection. [MS-LS4-6]
	Readers theater	<i>Once Upon a Jungle</i> , by Laura Knowles and James Boast, includes dramatic pictures which illustrate how the circle of life supports a jungle ecosystem. The shortened text provides an easy transition to script reading; each new page can represent a new character. [MS-LS1-6]
	Poetry	<i>Seeds, Bees, Butterflies, and More: Poems for Two Voices</i> , by Carole Gerber, is a collection of nature-themed poems designed to be performed in multiple voices. The rhythm and tempo of each poem mirrors the chirping of crickets or the buzzing of bees. [NGSS alignment varies by poem topic]
Evaluate	Two truths & one lie	<i>Tiny Little Rocket</i> , by Richard Collingridge, is a picture book that takes readers into the cockpit of a rocket ship and zips them through the planets, stars, and space. At the turn of every page, readers will see a different part of our Solar System, allowing them to construct their two truths and one lie. [MS-ESS1-3]
	Interactive read alouds (pause for students to explain or predict)	<i>Wolf Island</i> , by Celia Godkin, describes the delicate predator-prey balance in a real-life island ecosystem. The story, based on actual ecological events, begins with a family of Canadian wolves leaving an island for several seasons. The ecological balance between plants, rabbits, and deer becomes unbalanced due to the absence of apex predators and is only restored by the return of the wolves. [MS-LS2-4]

Books that describe or explain scientific concepts, introduce and use academic vocabulary, contain accurate illustrations, and support students' interpretation of observations work well in this phase. High-quality nonfiction, informational trade books, field guides, and scientifically accurate fiction books can all support explain activities. For most students, text supplemented with pictures is more accessible than text that

is simply read aloud (Beltran, Sarmiento, and Mora-Flores 2013). Captivating pictures stimulate students' recall of real-world experiences and promote sophisticated reasoning about abstract phenomenon.

Selected books should tightly align with the state or national science standards and objectives of the lesson and be free from scientific errors. Interactive read alouds and scaffolded individual or small-

group reading of expository texts pair well with explain activities (see Figure 2).

Teachers should exercise caution when selecting books for use in the explain phase. Explain activities provide students opportunities to construct understanding and connect inquiry experiences, new vocabulary, and science concepts. Books that replace student explanations should be avoided.

Elaborate

Elaboration gives students an opportunity to use concepts and abilities developed in prior phases to extend, expand, and enrich their understanding. Real-world connections, transfer of learning, and application of content are key features of elaborate (Bybee 2014).

Trade books that present a challenge that motivates students to use what they have learned to solve a problem or that showcase applications of scientific content in real-world settings are excellent choices for this phase. Books that connect to authentic current or historical events illustrate that science is a fluid body of knowledge that is enlarged by new discoveries. Biographies that showcase science as a human endeavor, expose students to diverse cultures and perspectives, and help students understand that science is dynamic work well here, too.

Literacy strategies that support the elaborate phase include: claims, evidence, and reasoning statements, open mind portraits, readers theater, and writing poetry (see Figure 2). Teachers should exercise caution when selecting books for elaborate. Books that review content without enriching learning should be avoided.

Evaluate

Evaluation is designed to assess student knowledge of science concepts and abilities (Bybee 2014). During this phase, teachers provide feedback to students through formal and informal assessments.

Trade books that contain science misconceptions, errors, or exaggerations work well in evaluation because they allow students to evaluate their ability to identify and correct the inaccurate text or illustrations. In addition, books that review patterns across

a scientific concept or that include breaks between questions posed in the text and answers provided also allow opportunities for teachers to assess student learning. Strategies such as two truths and one lie and interactive read alouds can tease out student learning (see Figure 2). Books that do not contain content errors, review patterns, or include natural breaks for questions and answers should be avoided.

Literacy strategies for science instruction

Once teachers have selected a book that is appropriate for one of the 5E instructional model phases, they need to decide how they are going to use that book in their science lesson. We recommend using one of the following literacy strategies to elicit student thinking. Figure 2 provides literacy strategy examples aligned with the 5E instructional model and the NGSS.

Strategy 1: First line

First Line may be used to activate prior knowledge by focusing student attention on the beginning line, sentences, or stanza of a book or poem. After listening to or reading the first line, students make and share predictions about the content covered in the book or poem. Teachers can use students' predictions to formatively assess students' initial conceptions and use of academic vocabulary. You may return to the book during the explain phase to evaluate and revise students' original predictions.

Modifications. Depending on the length and difficulty of the selected text, teachers may choose to read the text aloud, display it on a document camera, or make copies of the text and have students read the text individually or in small groups.

Strategy 2: Picture preview

A picture preview is a teacher-guided prereading activity. Before reading a book, the teacher supports students in "taking a walk" through the illustrations and/or photographs in the book. Students develop their own meaning about the key details

of each picture via observations and extend these observations through inferences and predictions (Richardson 2016). This strategy stimulates student interest in a topic and activates prior knowledge without explicitly teaching new content. If the text of the book is appropriate for the engage phase, you may choose to read the book directly after completing the picture preview. Alternatively, you may return to the book during the explain phase to evaluate and revise students' original interpretations of the pictures.

Modifications. For English learners or struggling readers, choose books with clear illustrations, simple photographs, and sight words that support the pictures. Also consider books with pictures that could have multiple descriptions or labels, such as plant/flower/dandelion/weed.

Strategy 3: Book talk

A book talk may include a brief overview, short book excerpts, or introduction of a book that motivates students to want to learn more about the content covered in the book or discover how the book ends. Teachers can use book talks to create a reason for future inquiry-based investigations of a science concept or phenomenon or probe students' initial

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understanding of science content. They can also return to the book later in the lesson during the explain phase and integrate the full text with students' explanations of the data from explore activities. Teachers may choose to wrap up the book during the elaborate phase as part of a formal in-class activity or as an individual out-of-class assignment.

Modifications. Depending on the length of the text, teachers can make copies of the text so that students can follow along. Alternatively, they can use a document camera to display the text as it is read.

Strategy 4: Think aloud

Thinking aloud is a literacy strategy in which the teacher makes their thinking public by demonstrating for students how expert readers construct meaning from text. Teachers select a brief, engaging section of text related to the lesson objectives. They set



up the think aloud by briefly summarizing the book and plot. Then, they read the selected text slowly and stop frequently to think aloud modeling strategies expert readers use to construct meaning: questioning, predicting/infering, reflecting, connecting, monitoring understanding, and visualizing.

Modifications. Depending on the length of the text, teachers can make copies of the text so that students can follow along or use a document camera to display the text as it is read. Or, they may decide to select a shorter section of text and read it very slowly. One key place to pause is when you encounter new vocabulary as students often need support inferring the meaning of individual words from the broader context of what they are reading (Graves, August, and Mancilla-Martinez 2013).

Strategy 5: Interactive read aloud

Read alouds are traditional classroom routines. Interactive read alouds enhance comprehension as teachers facilitate book discussions by asking students targeted questions at predetermined stopping points (Richardson 2016). When teachers use this literacy strategy during the engage phase, they must ensure that the book they select to read aloud will capture students' attention and activate prior knowledge without directly teaching the science concepts or new vocabulary that students will discover later during their explore activities or explain discussion. Stories with clear, understandable plots and familiar vocabulary are ideal when employing this strategy (Trelease 2013).

In explain, pause at predetermined points and discuss key concepts related to the explore activity. Students can use graphic organizers to keep track of main ideas or crosscutting concepts. During the evaluate phase, pause at predetermined points and ask students to complete an idea from the text, answer questions, or make predictions.

Modifications. Including a variety of questions allows all students to participate. Consider using a range of questions that require simple recall answers, and ask students to compare and contrast, to make deeper connections, and to think beyond the text.

Strategy 6: Claims, evidence, and reasoning statements

Claims, evidence, and reasoning (CER) statements frame scientific arguments. The NGSS suggest that inquiry includes planning and carrying out investigations so students can “generate data to provide evidence to support claims they make. Data aren't evidence until used in the process of supporting a claim” (NGSS Lead States 2013).

Modifications. Teachers may provide word banks and/or CER sentence stems that students use to complete CER statements. Students may also work in pairs or in small groups to prepare CER statements.

Strategy 7: Open mind portraits

Biographies that showcase science as a human endeavor and help students understand that science is dynamic are good choices here. Students create open mind portraits after reading a biography of a scientist. Students sketch a head and neck portrait of the scientist featured in the biography. Open mind portraits contain drawings, symbols, and captions that represent the scientist's thoughts, activities, and key contributions to science.

Modifications. Depending on the length and difficulty of the selected trade book or biography, teachers may choose to read the entire trade book, or selected text, aloud while students work individually, in pairs, or in small groups to complete their open mind portraits.

Strategy 8: Readers theater

Readers theaters are scripted dramatic presentations or multipart read alouds that incorporate text from books or other written material. They employ “theatrical techniques without the hassle of props, costumes, or sets. Instead of memorizing lines, students read directly from scripts, using intonation, facial expressions, and gestures to create characters that transport the audience into the story” (Stewart 2008, p. 99).

Modifications. Teachers can create readers theater scripts or students can work in pairs or small groups to adapt selected texts or books into readers theater scripts.

Strategy 9: Poetry

Poetry provides mentor text structures (examples) that students can use to write original free verse poems, multi-voice poems, cinquains, acrostic poems, or haikus. Poems may be used to introduce a science topic to engage or as a creative application of learning in elaborate. Poems are usually read aloud or “performed” by individual students or groups of students. In lieu of clapping, appreciation for poetry is expressed by snapping fingers.

Modifications. Students can work individually, in pairs, or in small groups to write and present their poems.

Strategy 10: Two truths and one lie

Trade books containing science misconceptions, errors, or exaggerations work well in evaluation because they allow students to evaluate their ability to identify and correct the inaccurate text or illustrations. Two truths and one lie evaluates learning when used with a book containing misconceptions, errors, or exaggerations.

Modifications. Depending on the length of the text passage, teachers can make copies of the passage so students can follow along or use a document camera to display the text passage as it is read. Students can work individually, in pairs, or in small groups to identify two truths and one lie, inaccurate text, science misconceptions, errors, or exaggerations.

Conclusion

Using trade books to support science instruction is a time-honored tradition. Books can spark interest in a science topic, introduce a problem to be investigated, challenge alternative conceptions, and expand students’ understanding of scientific concepts (Varelas et al. 2014). Classroom and school library collections are likely filled with hundreds of high-quality trade books that are ready resources teachers can use to create and enhance inquiry science experiences. ●

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RESOURCES

- Outstanding Science Trade Books for Students K–12—
<https://www.nsta.org/outstanding-science-trade-books-students-k-12>
- AAAS/Subaru SB&F Prize for Excellence in Science Books—
<https://www.sbfprize.org>

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