

A Guide to Developing Literacy Practices in Science

Analyzing Visual Representations: How Earthquakes Cause Tsunamis

Strategy Guide

The Learning
Design Group



THE LAWRENCE
HALL OF SCIENCE

Earth Science

Grades 6–8

Overview

What's in this guide? This strategy guide introduces an approach for teaching how to analyze visual representations in science texts. By using a method called Active Reading, students annotate the text and visual representations to highlight important information. They learn to interpret elements such as captions, keys, and arrows in order to analyze the visual representations in the article. This guide includes a plan for introducing students to visual representations with the article *Disaster in Japan: Earthquake and Tsunami*, which includes a time–sequence diagram of how powerful earthquakes at subduction zones can cause tsunamis.

Why analyze visual representations? Understanding information presented in visual representations (such as diagrams, charts, maps, graphs, and photographs) is a vital part of understanding science texts. Scientists often present their thinking visually, so it is critical that students gain the ability to analyze ideas presented in this manner. Research indicates that students do not attend to the visual representations in texts very carefully, so it is important to explicitly draw students' attention to them. Through modeling and practice, students learn to interpret text and visual representations simultaneously—this helps students realize that the most powerful understanding comes from connecting the two.

How This Fits Into Your Science Curriculum

Students will get the most out of the *Disaster in Japan: Earthquake and Tsunami* article if it is used as part of an instructional sequence on geological processes that shape Earth's surface. Reading this article can reinforce concepts about tectonic plate movement and help students see the impact that geologic activity has on Earth's surface as well as on human life. Before reading the article, students should know that Earth's surface is composed of different types of crust—oceanic crust and continental crust. Students should also have some knowledge about the different types of movement at plate boundaries.

Addressing Standards

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth: Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.

ESS2.A: Earth's Materials and Systems: The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

Crosscutting Concepts

Systems and System Models: Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information: Critically read scientific texts 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).

COMMON CORE STATE STANDARDS FOR ELA/LITERACY

Reading Standards for Literacy in Science and Technical Subjects 6–12

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

RST.6–8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Science Background

The *Disaster in Japan: Earthquake and Tsunami* article is about **subduction** zones, which are often the location of strong **earthquakes**, volcanic activity, and **tsunamis**. A subduction zone is a type of convergent boundary where at least one of the plate edges is made of **oceanic crust**. When the plates meet, the more **dense** crust is subducted, or pushed under, the less dense crust. In the case of an oceanic–continental boundary, the more dense oceanic crust is subducted. If both plate edges are made of oceanic crust, the older and denser crust is subducted under the newer crust into the **mantle**. Even though **tectonic plates** move at an extremely slow rate, the movement is responsible for the changing landscape of Earth's surface. The country of Japan is particularly susceptible to earthquakes due to the fact that it is located close to the boundaries of four tectonic plates. In March 2011, a huge earthquake off the coast of Japan triggered a tsunami that caused extensive destruction and loss of lives.

Getting Ready: Day 1

1. Read the *Disaster in Japan: Earthquake and Tsunami*, article and prepare to model Active Reading. Make sure you have a way to project the article during class. (For more information about Active Reading, see the Engaging with Text Through Active Reading: Wind Currents strategy guide.)
2. Make one copy of the article for each student.
3. On chart paper, record the Active Reading Guidelines and post them where they will be easily visible to all students.
4. On the board, write "What causes earthquakes?"

Activating Background Knowledge (5 minutes)

1. **Pose question.** Have students think about the question you wrote on the board: *What causes earthquakes?* Ask them to think about what they know that will help them answer this question.
2. **Students respond.** Ask students to record their ideas about the question individually. Alternatively, you could ask students to discuss their ideas with a partner.
3. **Debrief.** Lead a class discussion in which volunteers share their responses to the question.

Modeling Active Reading (10 minutes)

1. **Introduce the article.** Explain to students that they will read an article about a large earthquake and tsunami that happened off the coast of Japan in 2011. If necessary, explain that a tsunami is a huge wave caused by an earthquake or volcano under the seafloor.
2. **Refer to the Active Reading Guidelines.** Read each guideline aloud with students. Explain that students will read carefully, annotating the text

with questions, comments, and connections.

Explain that the purpose of doing this is to help them understand the text more deeply.

3. **Project the first page of *Disaster in Japan*.** Read aloud the title and subtitle. Say, "**The subtitle made me wonder about how it's possible that an earthquake and a tsunami can happen at the same time. I will write this down so I can keep a record of what I was thinking.**" Circle the subtitle and write "How can an earthquake and a tsunami happen at the same time?" Explain that you will read on to see if your question is answered later in the text.
4. **Read the first two sentences aloud.** Say, "**It says here that subduction caused the earthquake. I wonder if it caused the tsunami as well.**" Next to the second sentence, write "Did subduction cause the tsunami, too?"
5. **Call attention to the map on page 1.** Say, "**I think this map shows where the subduction zone is, so I will make sure to look at it carefully. I see that the arrows show the Pacific Plate subducting beneath, or going under, the North American Plate.**" Circle one of the arrows and write "Pacific Plate goes under." Let students know that they should pay particular attention to the maps, diagrams, and other visual representations in this article as these will help them better understand the text they are reading.
6. **Remind students to read carefully and independently.** Explain that students should read carefully and annotate the text, as you just modeled. Explain that after reading the text, they will be expected to share some of their thinking with a partner.

Reading and Annotating (15 minutes)

1. **Students read and annotate.** Allow time for students to read the text individually and make annotations. Encourage students to ask questions, make connections and comments, and record their annotations as they read.
2. **Make note of annotations.** You may want to make a note of interesting annotations and consider projecting them to share with the class, particularly those that students make on the visual representations.

Discussing Annotations (15 minutes)

1. **Review sharing annotations.** When most students have finished reading the article, have them discuss their annotations with a partner. They should work together to answer any questions they had to better understand the text. They should use the following procedure.
 - **Partner #1 chooses an annotation to share.** Partner #1 makes a star next to the annotation he chooses to share first. If it is a comment or a connection, he should explain why it was important to record. If it is a question, he should explain why he asked it.
 - **Partner #2 responds.** If it is a question, both partners work together to try to figure out an answer. This might mean rereading part of the text.
 - **Mark the annotation.** Partner #1 places a check mark near the annotation if he feels that discussing this annotation has helped him better understand it. He should circle the annotation if he would like to discuss it further with the rest of the class.
 - **Switch roles.** Partners then switch roles and follow the same procedure. Students should continue discussing annotations until time is up.
2. **Pairs discuss annotations.** Have pairs begin discussing their annotations. Circulate to listen and make note of particularly relevant and interesting discussions. These may include ideas about how subduction works, connections that demonstrate understanding concepts about plate tectonics, etc. Discussions could also include questions that students answered

by going back to the text or by calling on prior knowledge. You may even want to choose a discussion that centered on a visual representation, which could serve as a preface to the next session.

3. **Discuss annotations as a class.** Have volunteers share highlights of their discussions and how their discussions helped them better understand the text. Ask them what questions they still have and make note of these. Use this time to add your observations of particularly productive conversations or interesting questions that you overheard.
4. **Collect articles.** Collect students' annotated articles. You will select a few annotations on visual representations to use as examples in the next session.

Getting Ready: Day 2

1. On chart paper, record the Features of Visual Representations and post them where they will be easily visible to all students.
2. Using students' annotated articles from the previous session, find a few examples of high-quality annotations to use as models. In particular, find some examples of annotations that students made on the visual representations. Make sure you have a way to project or display students' annotations during class.
3. Make sure that the Active Reading Guidelines are still posted in the classroom.
4. On the board, write "Why do people sometimes use pictures instead of words to convey a message?"

Instructional Suggestion

Showing students' work can be a powerful teaching tool. Middle school students tend to be more interested in the process of Active Reading when real work from their peers is shown and discussed. This is especially useful when the chosen work is exemplary of some skill or type of thinking that students are learning to master in class. By choosing students' work to examine before or after engaging in Active Reading, students are presented with possible ways to engage with the text that they may not have considered on their own. In this way, students can learn from one another's reading methods and ideas.

Supporting English Language Learners

Some students may benefit from being introduced to familiar, everyday visual representations before analyzing scientific visual representations. Consider locating one or more diagrams with which your students may be familiar, such as a stadium seating chart, a map of a local park, or a diagram of a sports play. Show the visual representation(s) to students and ask them to tell you what they think it is and what the various parts of the diagram mean. For each piece of information students provide, ask, "How do you know that?" Have students explain how they got information from different elements of the diagram such as the colors, arrows, or labels. Then, ask other questions that rely on analysis of the visual representation. Be sure to draw the parallel between reading diagrams in everyday life and reading them in science texts. Encourage students to use what they know to read scientific diagrams.

Activating Background Knowledge (5 minutes)

1. **Pose question.** Direct students' attention to the question on the board: *Why do people sometimes use pictures instead of words to convey a message?*
2. **Students respond.** Allow a few minutes for students to think about and record their responses to this question individually.
3. **Debrief.** Call on students to share their responses. Accept all responses, highlighting any that mention that conveying messages in pictures is often more efficient or would help add to the message presented in a text.

Introducing Visual Representations (10 minutes)

1. **Explain the importance of visual representations.** Define visual representation as all images included in a text, such as the diagrams, charts, maps, graphs, and photographs. Explain that visual representations in science are used to help readers better understand scientific ideas. In particular, diagrams are especially helpful for showing how something works. As students may have pointed out earlier, many ideas that are presented in visual representations would be much more difficult to explain in text.
2. **Project students' annotations.** Show the class a few examples of students' annotations about

the visual representations in the article. Ask students to explain aloud the thinking behind their annotations. Let all students know that today they will make similar annotations to help them understand how earthquakes cause tsunamis, the central idea of the article.

3. **Project the second page of the article.** Direct attention to the time–sequence diagram. Ask a few volunteers to share what they observe. Highlight responses that point out features of the diagram, such as labels and colors.
4. **Review the Features of Visual Representations poster.** Point out the features that are represented in the time–sequence diagram: colors, arrows, labels, and captions. Explain that students will look carefully at these features in order to help them understand the diagram.
5. **Model analyzing the diagram.** Say, "For example, I can see that the first image in the time–sequence diagram shows two convergent plates. I know this because there are two arrows pointing toward each other, which indicates that the plates are moving toward each other. By looking at the labels, I can also see which plate is subducting." Ask students to tell you what else they can observe in the first image.
6. **Set purpose for rereading.** Explain that students will reread the article and pay particular attention to this time–sequence diagram on page 2, using its features to help them understand it more thoroughly.

Reading for a Purpose (10 minutes)

1. **Students read.** Have students reread the article. Encourage all students to make connections between the text and the visual representations.

Applying Understanding: Creating Captions and Labels (20 minutes)

1. **Explain the task.** Explain that students should add their own additional captions and labels to the remaining three images in the time–sequence diagram to show that they understand how the tsunami in Japan was formed.
2. **Model adding information to the diagram.** Explain that the time–sequence diagram provides some information about how tsunamis are formed and that you are going to add more information from the text of the article. Think aloud as you do the following:

Connecting to Standards

Analyzing visual representations is an approach that capitalizes on the overlap between the science practices in the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) for English Language Arts. One way that analyzing visual representations meets these standards is through highlighting the central science ideas of the text. Analyzing the time–sequence diagram in the article gives students the opportunity to critically read texts in order to obtain and describe evidence about the natural world (NGSS Science Practice 8: Obtaining, Evaluating, and Communicating Information) and helps students integrate information expressed in words with the same information expressed visually (CCSS.ELA–Literacy.RST.6–8.7). Analyzing visual representations also allows students to evaluate information in diverse formats to reveal deeper explanations and analyses (CCSS Anchor Standard 7 for Reading).

- Say, “I read on the first page of the article that Japan is near a plate boundary where the Pacific Plate is subducting under the North American Plate. I will use this information to label the plates in this diagram.” Label the Pacific and North American Plates on the first image of the time–sequence diagram.
 - Say, “I also read that the more dense plate is subducted under the less dense plate. Since the caption is about how plates move, I will add that information to the caption.” Write “The more dense plate is subducted under the less dense plate.”
3. **Students add captions and labels.** Have students work with partners to add additional information to the captions and labels for each of the three remaining images in the diagram. Let them know that they should refer back to the text as they are working. Remind them to first examine the features that are used in the time–sequence diagram in the article and then add more information to demonstrate their understanding.
 4. **Pairs discuss ideas.** Have pairs join with another pair to form a group of four. Instruct group members to share their augmented visual representations with one another. If they disagree about a feature, tell them to refer to the text and the diagram to explain their

thinking. Remind students to be open to revising their additional features, if necessary. Make note of groups that have particularly productive conversations, such as those who went back to the text to help explain their thinking.

5. **Call on volunteers to share.** Regain students’ attention and ask pairs to share their captions and labels with the whole class. Encourage them to be specific about how they used the features of the visual representation as well as the information presented in the text.
6. **Project page 2 of the article and review the time–sequence diagram.** Summarize the discussion by having students review how tsunamis are formed, as shown in the visual representation. Encourage students to use scientific vocabulary when explaining their ideas.
7. **Reinforce importance of visual representations.** If there were any questions that surfaced in students’ annotations that were answered by examining this visual representation, be sure to highlight these and point out how they helped students understand the important ideas.
8. **Extend learning.** As an extension or as homework, have students examine the map on page 1 of the article in order to demonstrate the importance of using the key to interpret color on the diagram. Ask students to write a short response to the question *Where in Japan do you think is the safest place to live?* Have them use the map and the article to support their responses.

Rereading for Understanding

One important factor in improving students’ understanding of science texts is getting students in the habit of reading deeply and developing persistence as they read. Often, students are not asked to read a piece of text more than once. However, rereading is a strategy that is important not only for understanding the text, but also for learning how to read the same text for different purposes (e.g., to answer a question or to find a specific piece of information). A good practice is to have students read the entire text once in order to get an overall understanding, record their questions and connections, and think through the ideas presented. Then, students should reread the text (or part of the text) for a specific purpose. Set the expectation that in science class, text is a resource for finding information and evidence, which may mean that it should be read more than once.

Generalizing This Practice

Analyzing visual representations is an important skill to emphasize throughout your science curriculum, particularly given the many ways that visual representations are used in science. Be sure to consider the types of visual representations that are common in the area of science that you are teaching. For example, time–sequence diagrams and cross–section diagrams are often found in Earth science texts, whereas magnified photographs are more prevalent in life science texts. Use the following steps to teach analysis of visual representations with other science texts.

- 1. Select an appropriate text.** The text should be related to scientific concepts that students have been studying. For the purposes of introducing and practicing the skill of analyzing visual representations, the text should not introduce new information. The text should include visual representations of one or more types (e.g., maps, cross–section diagrams, time–sequence diagrams). If the text is longer, identify a section of text and the associated visual representation on which you will focus after students have had the chance to read the entire piece through once.
- 2. Activate background knowledge.** Begin by showing students an interesting visual representation from the article or from another source and asking them what they notice. Encourage students to help you interpret the visual representation by pointing out features and by using their background knowledge about the topic.
- 3. Introduce the Features of Visual Representations poster.** Explain that visual representations have features that provide information about the concept—colors, labels, arrows, captions, etc. Point out these features on your example visual representation.
- 4. Students read the entire text once.** Have students read the entire text carefully, making annotations as they go. Have them pay special attention to the visual representations. After reading, debrief questions, comments, understandings, and misconceptions with the class.
- 5. Explain purpose of visual representations in science.** Explain that visual representations in science are meant to represent important ideas. Visual representations can present information that is also in the text, or they can add to ideas in the text.
- 6. Reread the text with a purpose.** Have students carefully reread the selected section of the text for the purpose of looking carefully at and analyzing the visual representation. You may want to provide students with a question that can be answered by analyzing the visual representation (e.g., *How do earthquakes cause tsunamis?*).
- 7. Students analyze visual representations.** Have students work in pairs or small groups to link together the information in the text and the visual representation in order to delve more deeply into understanding the concept presented. Allow time for students to talk through the features of the visual representation and build their understanding of it.
- 8. Apply understanding.** After students have the opportunity to work with visual representations, encourage them to synthesize their understanding of the concept orally or in a written response. You could pose a question that requires them to use the visual representation in order to answer the question, have them add missing features (such as a title, captions, or labels) to a partially completed visual representation of the same idea, or have them make their own visual representations to explain the idea. Be sure to prompt students to include features such as captions, arrows, color, and labels.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. Ask questions, make connections, and make comments as you read. Write these down to keep a record of your thinking.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. Discuss what you read with others to help you understand the text.

Features of Visual Representations

Look carefully at the visual representations (photographs, diagrams, illustrations, maps, graphs, or charts) as you read science texts. Think about what kind of visual representation you are looking at and what it is showing. Use the following features to help you figure out what the visual representation means.

Title: tells what the visual representation is about

Caption: one or two sentences that provide more information about the visual representation

Key: tells what the colors or symbols represent

Labels: give information about specific parts

Colors: represent different areas or parts

Lines: different lines can mean different things

Arrows: show direction, movement, or change

DISASTER IN JAPAN: EARTHQUAKE AND TSUNAMI

One of the strongest earthquakes ever recorded struck the coast of Japan in March 2011. This powerful earthquake was caused by subduction.

Japan is near a plate boundary where the Pacific Plate is subducting beneath the North American Plate. In this subduction zone, both plate edges are made of oceanic crust. However, the Pacific Plate is made of older, denser oceanic crust than the North American Plate. Because the Pacific Plate is denser, it is the plate that subducts.

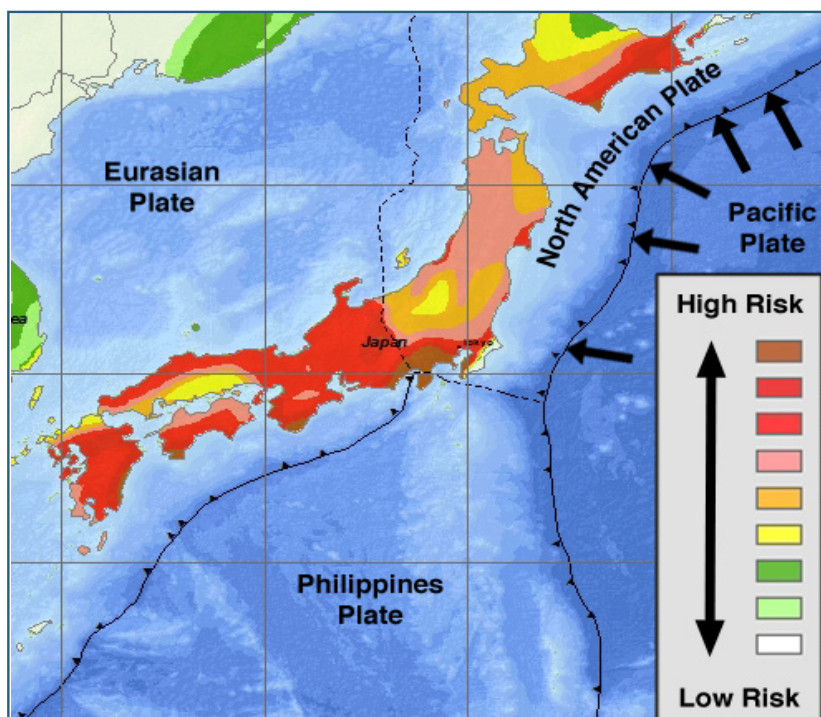
The Pacific Plate is moving toward the subduction zone at a rate of more than 8 centimeters (about 3 inches) per year. That's fast for a tectonic plate! Subduction of the Pacific Plate causes volcanic eruptions and strong earthquakes that start deep underground where the plate is being forced into the mantle.



Wikimedia/Tamaki Seto

The March 2011 earthquake caused a huge tsunami wave. The tsunami carried boats onto shore and destroyed buildings, roads, and whole towns.

Danger of a Major Earthquake

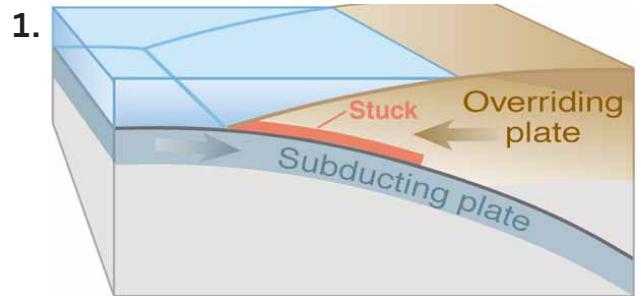


This map shows the plate boundaries near Japan. The colors represent the risk of strong shaking from earthquakes in different parts of Japan. Brown represents the highest risk.

USGS

The March 2011 earthquake was a huge disaster for Japan. More than 15,000 people died, and whole towns were destroyed. Scientists have used computer models to figure out exactly what happened during this earthquake. These models show that the earthquake raised a large area of the seafloor about 40 meters higher than it had been before the earthquake!

Because Japan's subduction zone is underwater, the earthquake was only the beginning of the disaster in Japan. When the earthquake suddenly lifted part of the seafloor, the rising seafloor pushed up a huge wave called a tsunami (sue-NAH-mee). The tsunami wave traveled quickly over the land, smashing buildings and carrying people away. It was the tsunami that actually caused most of the death and destruction.



Overriding plate (the plate on top) becomes stuck to subducting plate.

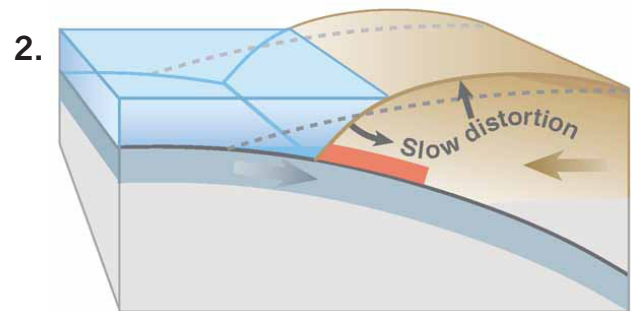
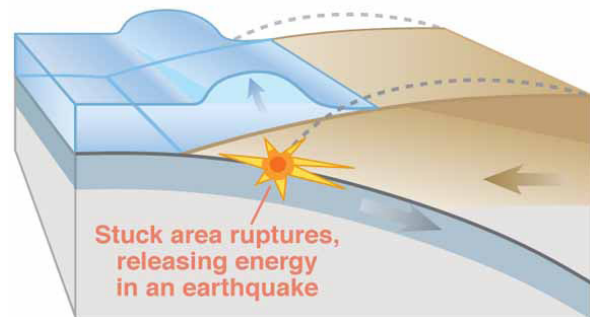
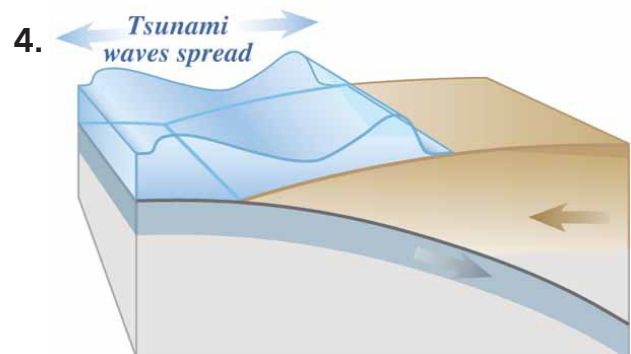


Plate on top bends because it is stuck.

3. *Earthquake starts tsunami*



Plates break free, producing an earthquake. The seafloor rises during the earthquake, creating waves.



Tsunami waves spread in both directions.

About Disciplinary Literacy

Literacy is an integral part of science. Practicing scientists read, write, and talk, using specialized language as they conduct research, explain findings, connect to the work of other scientists, and communicate ideas to a variety of audiences. Thus, the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) alike call for engaging students in these authentic practices of science. Through analyzing data, evaluating evidence, making arguments, constructing explanations, and similar work, students engage in the same communicative practices that scientists employ in their profession. Through supporting and engaging students in science-focused literacy and inquiry activities that parallel those of scientists, students master discipline-specific ways of thinking and communicating—the disciplinary literacy of science. Strategy guides are intended to help teachers integrate these disciplinary literacy strategies into the science classroom.

About Us

The Learning Design Group, led by Jacqueline Barber, is a curriculum design and research project at the Lawrence Hall of Science at the University of California, Berkeley. Our mission is to create high-quality, next-generation science curriculum with explicit emphasis on disciplinary literacy and to bring these programs to schools nationwide. Our collaborative team includes researchers, curriculum designers, and former teachers as well as science, literacy, and assessment experts.



The Learning
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