Britannica Expedition:LEARN!

Teacher Toolkit

Constructing and Interpreting Models: Grades 6–8

OVERVIEW:

People use models every day. From maps to toy cars and airplanes, to globes or diagrams in instructions, models are all around us. A model is a representation of something else, acting as a substitute for the real thing. Models can be diagrams, physical replicas, mathematical equations, analogies, or computer simulations. Models represent systems or parts of systems and are essential to science learning, understanding, and communication. They allow scientists to make predictions and construct explanations. In addition, they allow scientists to go beyond the visible world to show and describe objects that are too large, small, or fast for the human eye. Scientists also use models to represent things that don't exist anymore, things that have yet to be created, or things that are too hard to communicate with words.

Models are also essential to engineers, as they are used to visualize, design, and communicate design features to others. Engineers use models to evaluate systems, test prototypes for solutions, and analyze systems and designs for their strengths and limitations.

In middle school, students can use models to predict and explain the natural world as well as to describe the relationship between parts in a system or to explain how systems change over time. In addition, as students deepen their understanding of models and scientific concepts, they move to evaluating models, examining the merits and limitations of various models and connecting their evaluation to scientific rules and principles. Students can use this analysis to propose revisions and improvements to existing models.

Mini-Lesson I

Interpreting Models (15 minutes)

Background: Scientific texts frequently use models in order to convey ideas, concepts, or patterns. The ability to interpret models, understanding that they represent systems or parts of systems, are essential to students' growth as scientific readers and thinkers. The following teaching suggestions are based on the *Expedition: Learn!* lesson "The Water Cycle."

- Share with students that scientists often use models to represent how systems work or how a part of a system works. These models can be diagrams, computer simulations, mathematical formulas, or physical representations.
- Explain that in this lesson, students will study a model of Earth's water cycle and use the model to answer a question.
- Display the model "Earth's Water Cycle" on page 4-Build in the lesson. Invite students to turn and talk, discussing what they see.
- After a few minutes, invite students to share out, recording their thinking on the board. For example:
    - *sun, clouds, rain, mountains, river/stream, ocean/lake, trees*
- Ask students to use the model to write a few sentences explaining how Earth's water cycle works. Invite a student to share their explanation, for example:
    - *The Sun evaporates water from lakes and oceans, and that water creates clouds. The clouds eventually release precipitation (rain or snow) onto the land. This water runs down in rivers and streams into low ground or the lakes and oceans. Then the cycle begins again.*
- Invite students to turn and talk, answering the question:
    - How do the Sun and gravity impact the water cycle?
- Ask a student volunteer to share. For example:
    - *The Sun is what causes water to evaporate and creates the clouds. Gravity helps water to run down from the mountains and higher ground into lakes and oceans.*

Mini-Lesson II

Comparing Models to Identify Strengths and Limitations (30 minutes)

Background: Models play a valuable role in science, representing concepts that are too small to see, too slow to be observed, or otherwise abstract or hard to conceptualize. While models are important and useful, they also have limitations. As students develop their ability to construct and interpret models, it is important they build awareness of the limitations a model presents. One way to do that is to have students compare two models and use the comparison to identify limitations, connecting their analysis to the core scientific principle or rule. The following lesson invites students to analyze two models contained in the *Expedition: Learn!* lesson "Motion in Space." It is suggested that students engage with the lesson prior to completing the mini-lesson, since their ability to analyze models and their limitations relies on their understanding of the key disciplinary ideas.

- As needed, review the definition of model, emphasizing how students have previously used models in science.
- Reinforce for students that scientists use models for a variety of purposes, including representing objects that are too small to see, like atoms, or too large to see, like the solar system.
- Share that since models are simpler than the real objects or systems they represent, they have limitations, or weaknesses. Emphasize that part of scientific learning and thinking is analyzing models to determine their strengths and weaknesses.
- Distribute and display the **Comparing Models organizer**. Ask students to identify the core concept or scientific principle in the lesson and record it on their organizer. For example:
    - *Gravity affects the motion of the objects in space, including the Moon.*

- Introduce the first model, the diagram on page 3-Build titled "Motion of the Moon." Work through the questions, thinking aloud to analyze the model.
    - **Type of model**
        - *The model is a diagram.*
    - **What are the components/parts of the model?**
        - *The model shows Earth and the Moon. Lines and arrows represent the path the Moon takes as it orbits Earth. Arrows represent the gravitational pull the Moon and Earth have on each other.*
        - *The model represents the path the Moon takes because of the gravitational pull as well as the path it would take if there were no gravity.*
    - **How does the model connect to the core scientific principle?**
        - *The model represents the gravitational pull and interaction between the Moon and Earth. It shows how the path of the Moon's orbit is affected by gravity.*
    - **What are the limitations of the model?**
        - *Because the model is a diagram, it doesn't show the actual motion of the Moon or Earth. In addition, the model doesn't include any other objects that are in space and could influence the motion of the Moon.*
- Introduce the second model, the video "Gravitational Forces in Space" on 4-Build. Share that part of the video is a computer simulation that shows the motion of the Moon and Earth.
- Invite students to watch the video and then turn and talk with a partner to complete the organizer for the model. Sample responses:
    - **Type of model**
        - *The model is a simulation.*
    - **What are the components/parts of the model?**
        - *The simulation includes the Moon and Earth. It uses an arrow to show the gravitational pull between Earth and the Moon as well as to show the direction in which the Moon orbits.*
    - **How does the model connect to the core scientific principle?**
        - *Because the distance between the Moon and Earth never changes, the force of the gravity between the objects is constant. Since the Moon is smaller, it is pulled toward Earth, but its forward motion keeps it from falling into Earth and instead creates an orbit around Earth.*
    - **What are the limitations of the model?**
        - *The model does not include what would happen if the gravitational force were not there, nor does it show how other objects in space could potentially interact with the Moon and Earth.*
- After students have completed their analysis, facilitate a discussion in which students identify the similarities and differences between the models and explain which model they feel best represents the scientific concept.

Mini-Lesson III

Develop a Model (40 minutes)

Background: In middle school, students are expected to use and construct models to explain phenomena or to describe how things work in both science and engineering. Students will have built a solid understanding of how scientists and engineers use models in elementary school. Here they should engage in the process of constructing models and using them to explain phenomena. The following lesson is based on the *Expedition: Learn!* lesson "Parts of a Cell."

- Invite students to turn and talk to share the definition of a model and some examples. Share with students that they will work on constructing models today.
- Invite students to independently or collaboratively read the *Expedition: Learn!* lesson "Parts of a Cell." Upon completion, distribute and display the **Constructing Models graphic organizer**.
- Review each step of the process. Work with students to complete steps 1 and 2 before releasing them to work with a partner to complete the remainder of the steps. Sample responses:
    - **Step 1: Identify the phenomena or concept.**
        - *We are creating a model to describe the function of a cell as a whole and how parts of cells contribute to the function.*
    - **Step 2: Create a focus question. What is the model trying to show?**
        - Encourage students to think about how they can write their focus question(s) to be as precise as possible. For example: *How does an animal cell work? What is the function of each part of an animal cell?*
    - **Step 3: Define the components of the model. What does it need to show? What needs to be included?**
        - *It needs to show cytoplasm, the nucleus, vacuoles, the cell membrane, and the mitochondria. It should also show that the cell membrane is a barrier between the cell and the outside environment that allows helpful things to pass into the cell and keeps harmful things out. It should show that cytoplasm is the substance that all the organelles hang out in. It should show that the nucleus is the control center of the cell that contains the cell's genetic material. It should show that mitochondria break down food molecules to release the energy they contain. Finally, it should show that vacuoles carry food molecules, water, or waste products.*
    - **Step 4: Create a sketch of the model**
        - Students should draw the animal cell and use arrows and labels to show what each item is. They can include short descriptions of what each part of the cell does.
    - **Step 5: Review the model to consider the limitations and/or missing components.**
        - *Our model will not show the cell in action, so we cannot see how energy moves from the vacuoles to the mitochondria, or how the nucleus gets this energy. We will also not see how the cell membrane works to let some things in and keep other things out.*
    - **Step 6: Revise the model to elaborate on the initial idea.**
        - *We can add more detail to the model, like showing the path that energy takes from the vacuoles to the mitochondria to the nucleus by using arrows.*
    - **Step 7: Present the models to the class.**
        - Students can explain how their model shows how a cell functions and how each part of the cell contributes. They should describe any limitations or improvements they made.

Check for Understanding

If you observe ...	Then try ...
students struggling to describe what they see in a model	provide sentence stems to support their analysis and development of language. For example: • The model shows ___. • The ___ on the model represents ___. • The model represents ___.
students struggling to connect the model to a scientific concept.	brainstorm a list of key learnings related to the topic of study that students can draw from when connecting the model to a scientific concept.

Comparing Models

Scientific Rule/Concept: _____		
	Model 1:	**Model 2:**
Type of Model		
What are the parts or components of the model?		
How does the model connect to the core scientific principle?		
What are the limitations of the model?		

Constructing Models

Step 1: Identify the phenomena or concept.

Step 2: Create a focus question. What is the model trying to show?

Step 3: Define the components of the model. What does it need to show? What needs to be included?

Step 4: Create a sketch of the model.

Step 5: Review the model to consider the limitations and/or missing components.

Step 6: Revise the model to elaborate on the initial idea.

Step 7: Present the model to the class!