Britannica Expedition: LEARN!

Teacher Toolkit

Mathematical Reasoning: Grades 6–8

OVERVIEW:

Mathematics, computational thinking, and mathematical reasoning are tools for understanding science and evaluating engineering designs. Mathematical reasoning is associated with the skill of analyzing and interpreting data as students logically interpret results to explain phenomena and draw conclusions about engineering solutions. Students who can effectively use mathematical reasoning can more easily design experiments that address key questions and problems, recognize and compare important patterns in data sets, better connect experimental results to information they've learned through reading, and have a better understanding of how the analysis of empirical data contributes to advancements in scientific knowledge and technology.

Students are expected to use mathematical representations to make sense of data and support conclusions, organize and graph data sets using digital tools such as computer programs to reveal relationships between variables, and use mathematical concepts and processes, such as rates, percentages, and algorithms, to analyze quantitative data.

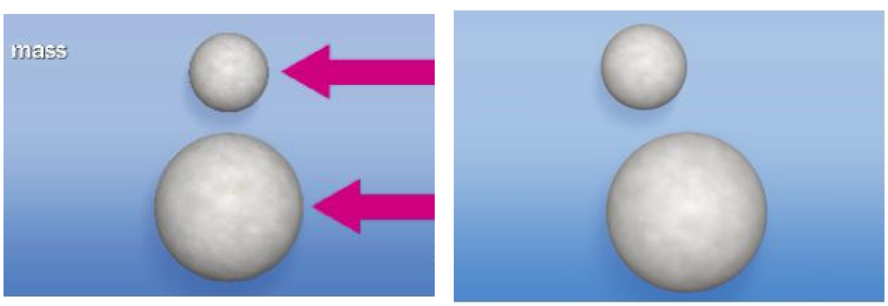
The following strategies are designed to scaffold and support students in mathematical reasoning concepts in Expedition: Learn! science texts. While each of the mini-lessons below are based on specific passages and lessons within Expedition: Learn!, they can be adapted to meet the needs of your classroom.

Mini-Lesson I

Qualitative Versus Quantitative Data (15 minutes)

Background: Mathematical representations are an important part of mathematical reasoning. Analysis of mathematical representations helps students find patterns and make generalizations about the relationships between variables. When students use mathematical representations to explain phenomena, their thinking and depth of knowledge become visible. The following teaching suggestions are based on the *Expedition: Learn!* lesson "Forces and Motion."

- Share with students that mathematical reasoning is an important part of understanding science.
- Explain that in scientific texts, students will often see mathematical representations. A mathematical representation is something that explains a mathematical idea or relationship.
- Being able to analyze mathematical representations can help students understand concepts, find patterns, and make predictions.
- Share that there are five main types of mathematical representations:
    - verbal - spoken or written representations
    - physical - concrete representation, such as 3-D models and manipulatives
    - visual - semi-concrete representations, including drawings, photographs, 2-D models, diagrams, and flow charts
    - symbolic - abstract representations that include numbers and symbols
    - contextual - representations that directly connect to real world situations
- Explain that students will look at three different representations from the lesson and discuss the similarities and differences between them.
- Share the first, a verbal mathematical representation:
    - If the same force is applied to two objects of different mass, the object with less mass will have a greater acceleration.
- Share the second, a visual mathematical representation:



- Finally, share the symbolic mathematical representation:
    - *F = m x a; a = F / m*
    - (force equals mass times acceleration; acceleration equals force divided by mass)
- Invite students to turn and talk to discuss what all three representations have in common. After a minute, invite students to share. Sample response:
    - *They all talk about force, mass, and acceleration. They all explain that if the same amount of force is applied to two objects of different masses, the object with less mass will have greater acceleration.*
- Ask students to think and jot a response to the following:
    - How do different mathematical representations help us to understand a concept? Sample response:
        - *Different representations can help people who think about things differently. The verbal representation can help people who think in words to understand the idea. The visual representation can help people who think better in pictures to understand. The symbolic representation can help people who think in symbols and numbers to understand. Combining all three can reinforce the idea the author is trying to express.*

Mini-Lesson II

Creating and Using Algorithms (15 minutes)

Background: Mathematical thinking and reasoning involves the use of algorithms to solve problems. Algorithms are a series of well-defined steps or instructions that are used to solve a problem. Algorithmic thinking is an approach to problem-solving that helps students understand scientific and engineering processes. It is also the basis for computer science and other STEM fields. The following teaching suggestions are based on the *Expedition: Learn!* lesson "Graphing and Describing Motion."

- Share with students that when scientists use mathematical thinking in their work, they often need to write in a way that allows other scientists to follow the same steps and test the same hypothesis, to see if they get the same result.
- Explain that one way that scientists achieve this is by using algorithms. Share the definition of algorithm:
    - *algorithm*: a set of actions or steps needed to solve a problem or perform a computation
- Refer to the lesson "Graphing and Describing Motion." Invite students to take a moment to look through the lesson and respond to the question:
    - How do I find the distance that an object has traveled?
- After a moment, invite a student to share their response:
    - *distance = speed x time*
- Explain that the equation distance = speed x time is an algorithm, or a set of steps to follow to find the distance an object travels. You need to know the speed an object traveled and how long it traveled for in order to find distance. Every person that enters the numbers will get the same answer.
- Provide students with the following information and ask how they would find the distance:
    - A train traveled at 100 miles per hour for three hours. What distance did it travel?
- Invite a student to share both the answer and how they found it. For example:
    - *The train traveled a distance of 300 miles. The speed it traveled was 100 miles per hour, and it traveled for three hours. 100 x 3 equals 300, so the answer is 300 miles.*
- Provide students with a second scenario, and invite them to turn and talk with a partner to find the answer:
    - A train traveled 100 miles in two hours. At what speed was the train traveling?
- Invite a pair to share both the answer and how they found it. For example:
    - *The train traveled a distance of 100 miles. We know it traveled for two hours. Since distance equals speed times time, we created the following equation: 100 =* s *x 2. Then we divided 100 by 2 to find* s*, the speed, and got the answer, 50 miles per hour.*
- Provide students with a final scenario and invite them to turn and talk with a partner to find the answer:
    - A train traveling at 50 miles per hour traveled 250 miles. How long did it take the train to go this distance?
- Invite a pair to share both the answer and how they found it. For example:
    - *The train traveled a distance of 250 miles. We know it traveled at 50 miles per hour. Since distance equals speed times time, we created the following equation: 250 = 50 x* t*. Then we divided 250 by 50 to find* t*, the time, and got the answer, five hours.*
- Emphasize that algorithms in scientific texts can help us to understand a concept and replicate a study that a scientist has conducted.

Check for Understanding

If you observe ...	Then try ...
students struggling to use algorithms	providing math supports such as calculators, and using drawings or simulations to help students understand the concept.