NGSS-Focused Summative Classroom Assessments of Three-Dimensional Learning

Maia Binding

NSTA - Chicago

July 22, 2022

SEPUP
Issue-Oriented Science

The Lawrence Hall of Science
UNIVERSITY OF CALIFORNIA, BERKELEY

CINGA Project Overview

- Curriculum Independent Next Generation Assessments (CINGA)
- Lawrence Hall of Science Project, led by SEPUP
  - FOSS, LDG, and Research staff are also participating
- Two-phase, four-year project finishing 12/2022
- Funded by Carnegie Corporation of New York
  - This work was made possible by a grant from the Carnegie Corporation of New York. The statements made and view expressed are solely the responsibility of the authors.

CINGA Project Overview

- **Goal:** Develop 2D and 3D summative curriculum-independent assessments similar in nature to those SEPUP developed for the *Disruptions in Ecosystems* Unit
- **Piloting:** Work with teachers to obtain input and pilot assessments in their classrooms
- **Expert review:** Teachers, curriculum and assessment experts
- **Availability:** Sample items will be on website, other groups have access through publishers, etc (e.g. SEPUP users via Lab-Aids, OSE users via CenterPoint)

Item Development Process

- Based on published approaches for Evidence-Centered Design of NGSS Assessment Development (Harris et al. 2016)
- Steps of the process include:
  - "Unpacking" the NGSS elements: SEP, CCC, and DCI
  - Development of Learning Performances (LPs)
  - Development of design patterns for the items, including
    - The nature of information provided in the prompt
    - Possible relevant phenomena/problems/scenarios
    - Possible supports to promote equity
  - Development of the specific items

Harris, C. J., Krajcik, J. S., Pellegrino, J. W., & McElhaney, K.W. (2016). *Constructing assessment tasks that blend disciplinary core Ideas, crosscutting concepts, and science practices for classroom formative applications.* Menlo Park, CA: SRI International.

Collecting Evidence about Validity and Reliability

- Review of items by representatives from three curriculum groups at the Lawrence Hall of Science
- Review of items by classroom teachers
- Review from additional curriculum groups
- Student cognitive labs (think-alouds)*
- Classroom piloting*
- Additional expert review

Earth Science

MS ESS2-4: Earth's Systems

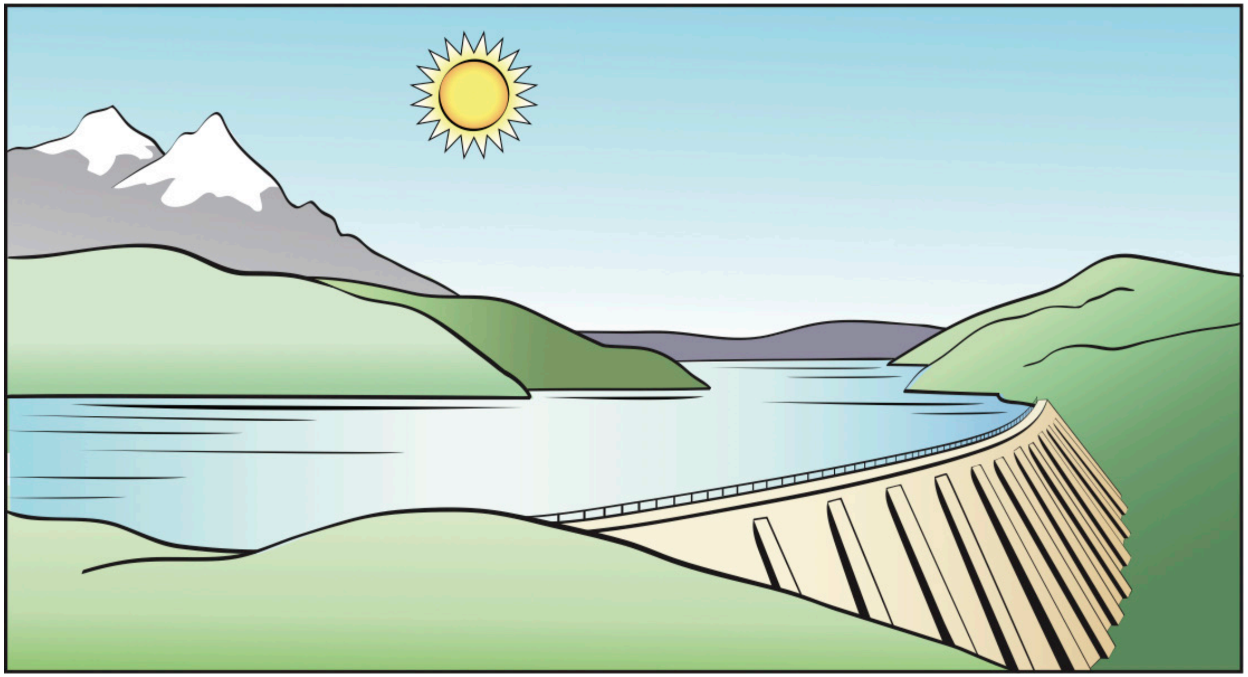
Students who demonstrate understanding can:

MS-ESS2-4. **Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.** [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [*Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity.	**Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

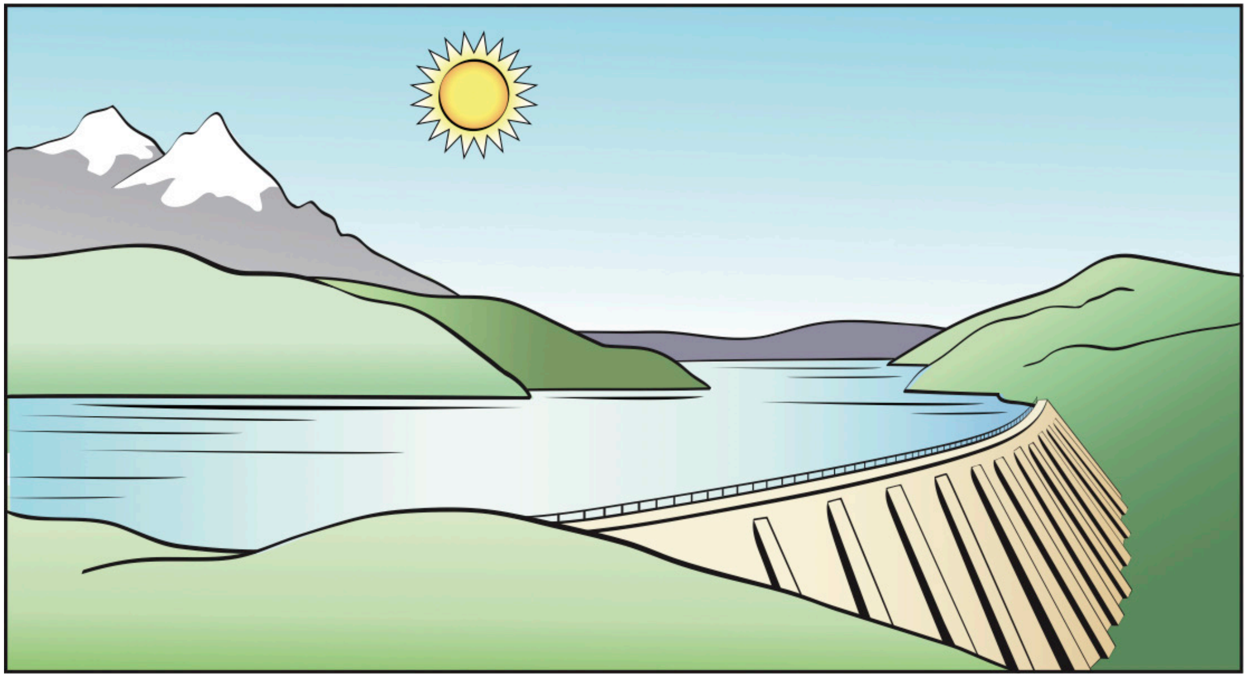
Example Learning Performance: Students create a model that shows how water gets from the surface to the atmosphere, from the atmosphere to a mountain or area of high elevation, and then to an area of low elevation.



The diagram above shows a reservoir, a large body of water built by people in the mountains.

How does the snow in the mountains end up as water in the reservoir? Add arrows and labels to the diagram to show your ideas:

- Show the phase the water was in along the way and any changes
- Explain any process that was driven by gravity
- Explain any process that was driven by a transfer of energy



SEP: Modeling

DCI: Water Cycle (sunlight, gravity)

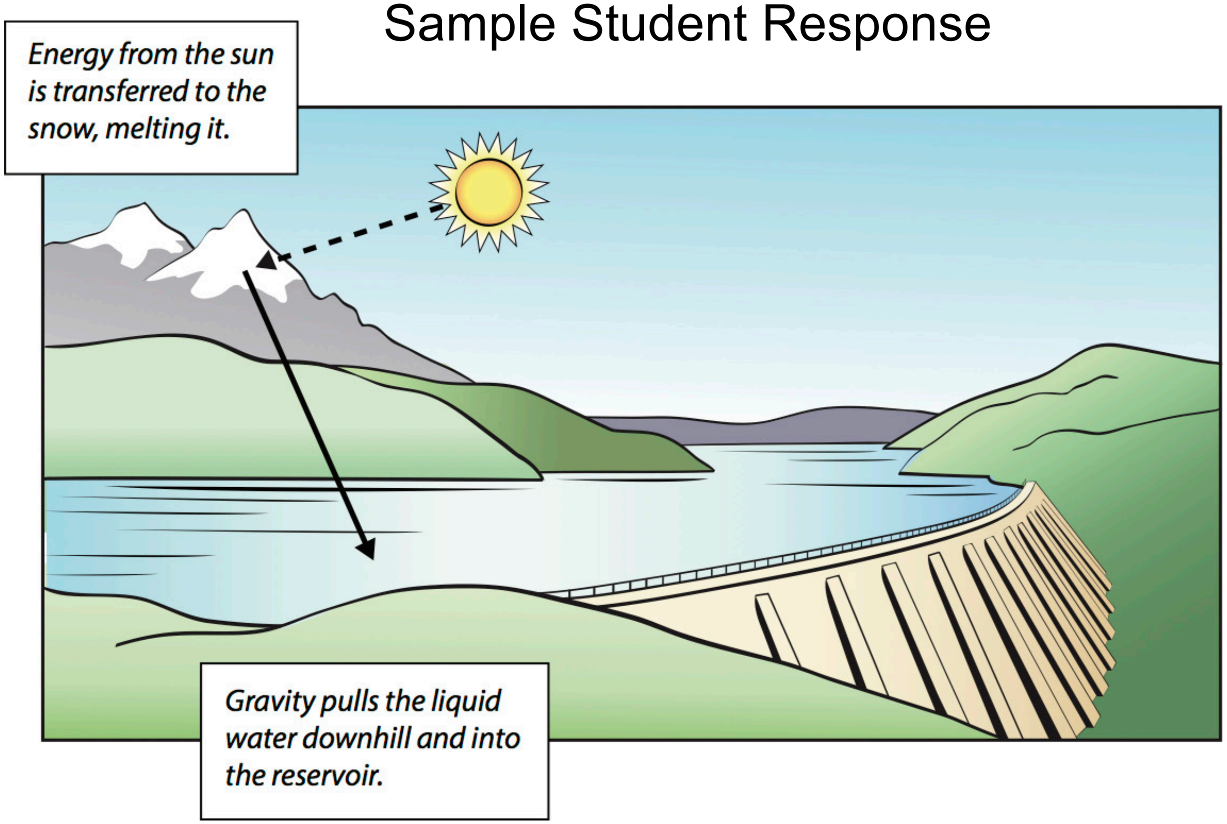
CCC: Energy & Matter

The diagram above shows a reservoir, a large body of water built by people in the mountains.

How does the snow in the mountains end up as water in the reservoir? Add arrows and labels to the diagram to show your ideas:

- Show the phase the water was in along the way and any changes
- Explain any process that was driven by gravity
- Explain any process that was driven by a transfer of energy

Sample Student Response



SEP: Modeling

DCI: Water Cycle (sunlight, gravity)

CCC: Energy & Matter

How does the snow in the mountains end up as water in the reservoir? Add arrows and labels to the diagram to show your ideas:

- Show the phase the water was in along the way and any changes
- Explain any process that was driven by gravity
- Explain any process that was driven by a transfer of energy

Questions…

- What challenges might students encounter?
- What supports might students need to engage in three-dimensional sensemaking as they respond?

Life Science

MS-LS1-5 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-5. **Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] *[Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]*

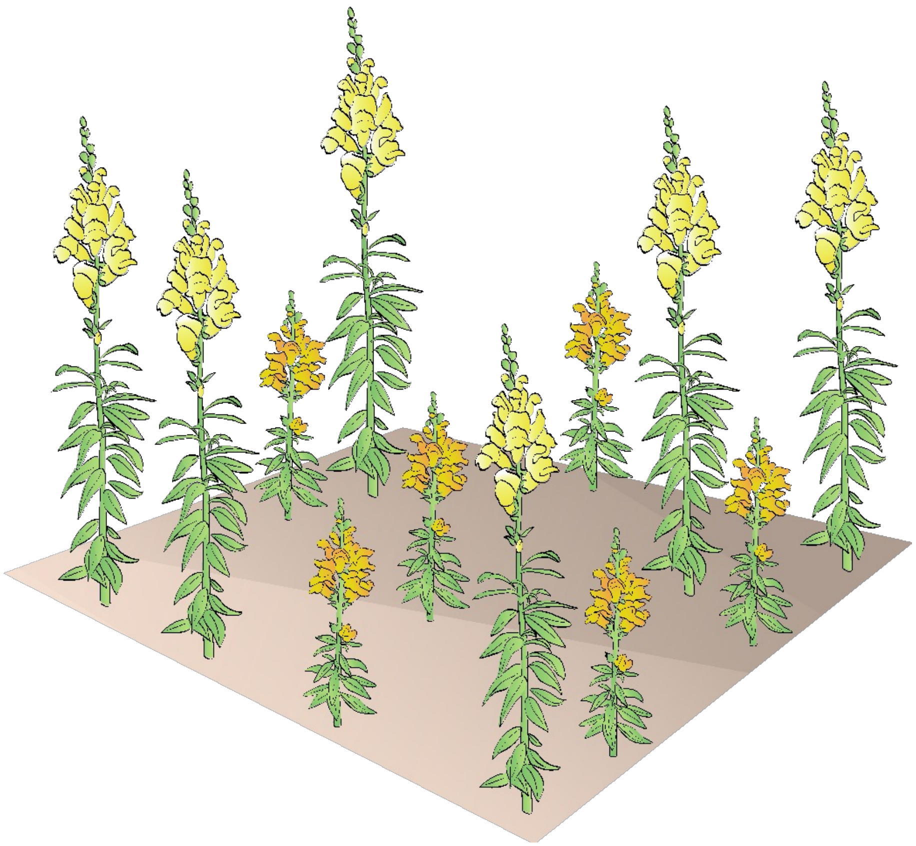
The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.B: Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Example Learning Performance: Given evidence about variations in the growth of a sample of plants, students construct an explanation for how *both genetic and environmental* factors might explain the differences observed.

Samira and her father go to the plant nursery and find 12 young plants that are labeled “yellow snapdragons.” They plant them in a sunny part of the garden and give them the same amount of water.

After 4 weeks, all the plants are healthy. But they are different heights and shades of yellow, as shown in the picture below. About half of them are dark yellow and short (about 18 cm), while the other half are light yellow and tall (about 45 cm). Since all the plants grew under the same conditions, what might cause the differences in the plants? Explain your answer.

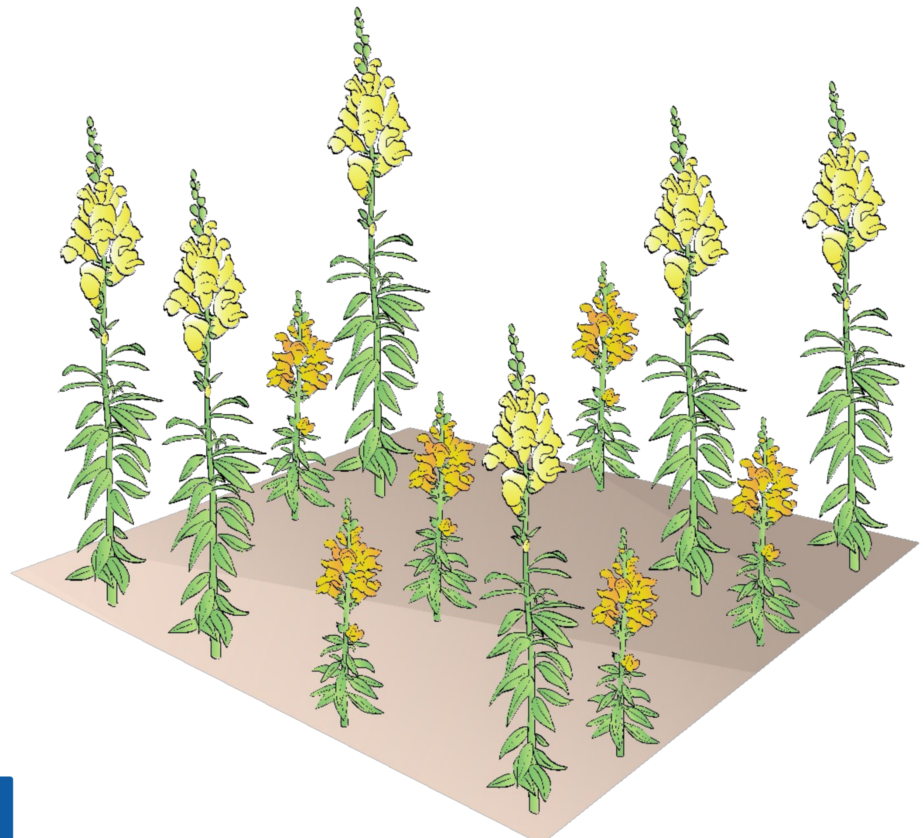


SEP: Explanation

DCI: Genetics & local conditions

Samira and her father go to the plant nursery and find 12 young plants that are labeled “yellow snapdragons.” They plant them in a sunny part of the garden and give them the same amount of water.

After 4 weeks, all the plants are healthy. But they are different heights and shades of yellow, as shown in the picture below. About half of them are dark yellow and short (about 18 cm), while the other half are light yellow and tall (about 45 cm). Since all the plants grew under the same conditions, what might cause the differences in the plants? Explain your answer.



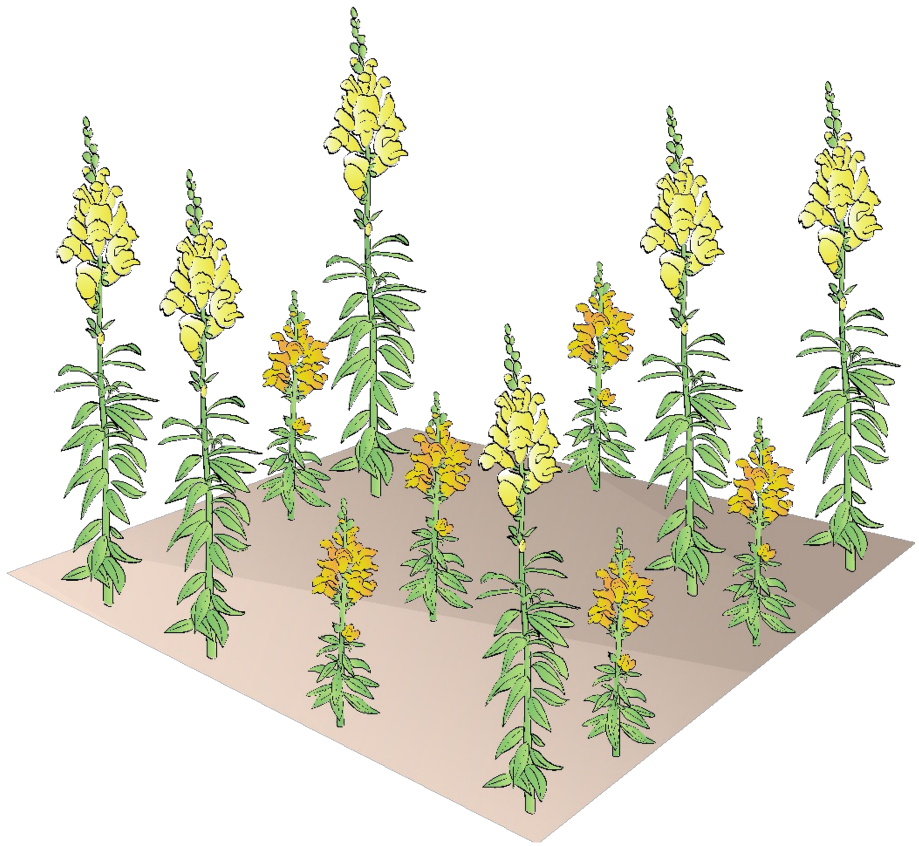
CCC: Cause & effect

Sample Student Response

Since the plants are all grown in the same conditions, the different heights and colors don't seem to be caused by the environment, so they might be caused by different genes. Genes can affect an organism's growth and appearance.

SEP: Explanation

DCI: Genetics & local conditions



CCC: Cause & effect

Scoring Guide

What to look for in all items:
• Response includes relevant evidence, disciplinary core ideas, and crosscutting concepts.
• Response logically links evidence and concepts to develop a causal mechanism for a phenomenon.

Scoring Guide - Item 1		
Level	**General Description**	**Item-Specific Description**
4 Complet e and Correct	Student's explanation • is supported by sufficient use of appropriate evidence and concepts* AND • links the evidence and concepts to provide a clear and complete causal mechanism for the phenomenon.	Student's explanation • includes the idea that factors that affect growth are genes and the environment, • includes the idea that the conditions in the three sizes of pots are in some way different, AND • explains that this is a change in the environment (or specified conditions) that causes the difference in growth, • does *not* need to give specific reasons such as water per amount of soil, etc.
3 Almost There	Student's explanation • is supported by sufficient use of appropriate evidence and concepts* BUT • does not link the evidence and concepts to provide a clear and complete causal mechanism for the phenomenon.	Student's explanation • includes the idea that factors that affect growth are genes and the environment, • includes the idea that the conditions in the three sizes of pots are in some way different, AND • attempts to relate this to the environment, but the explanation is not completely clear.
2 On the Way	Student's response • includes some use of evidence and concepts* relevant to the phenomenon BUT • some key pieces of evidence and/or concepts are missing.	Student suggests that conditions for growth are better in the medium-sized pots but does not relate this to environmental effects.

Physical Science

PS2-4: Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-4. **Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.** [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [*Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.*]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

- Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Disciplinary Core Ideas

PS2.B: Types of Interactions

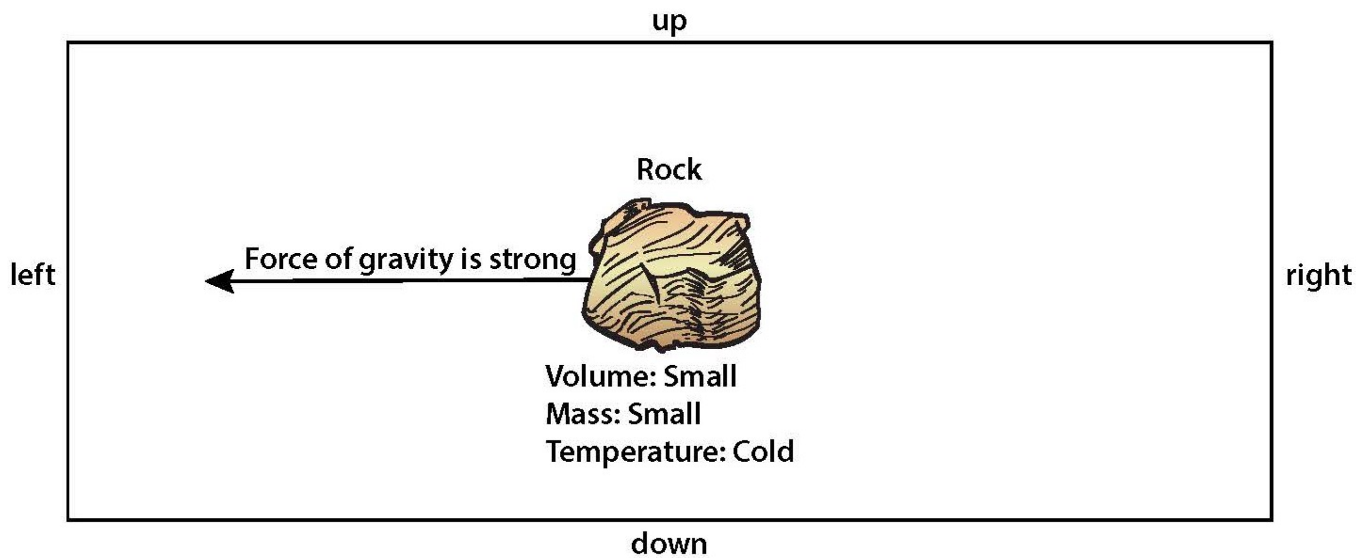
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.

Crosscutting Concepts

Systems and System Models

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

LP: Students can develop and use models to describe the force between objects due to the unobservable gravitational interactions.



The diagram above shows a rock in space. The diagram also shows that the force of gravity acting on that rock is strong and to the left.

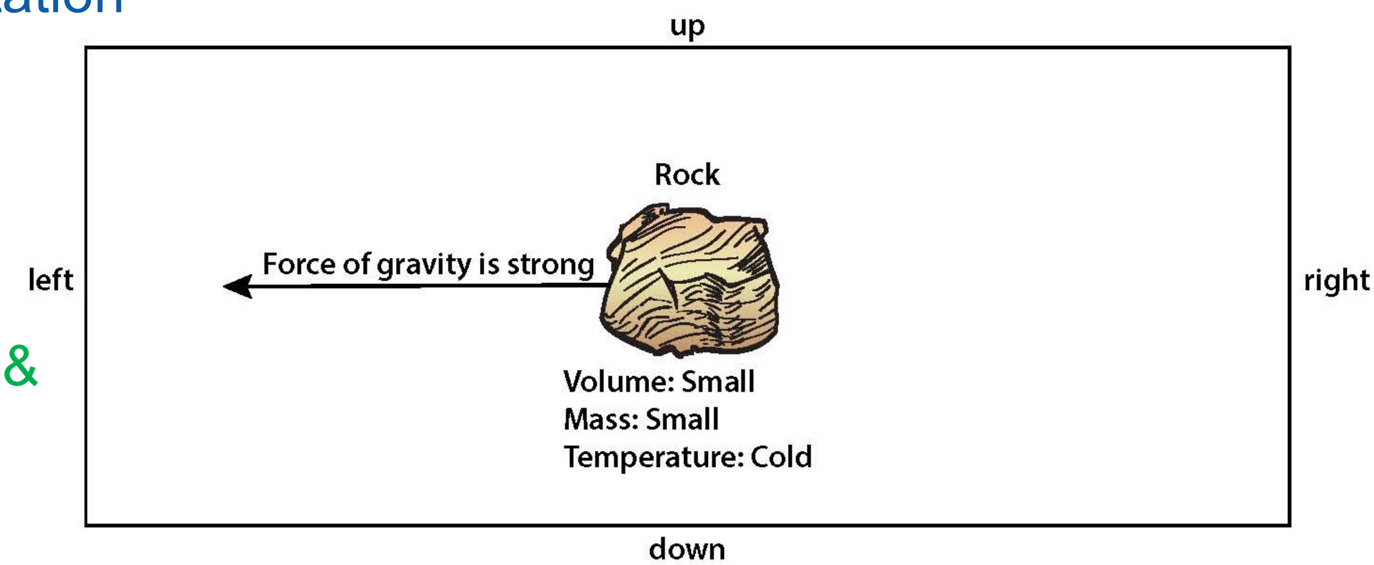
A news reporter wants to explain what is happening with the rock to her audience. She claims that the reason this force is strong and to the left is that there is another object to the left, and that object has a large mass.

Could this claim explain why the force of gravity is strong and to the left? What is your evidence, and why does it support or go against her claim?

SEP: Argumentation

DCI: Attractive gravitational forces

CCC: Systems & system models



The diagram above shows a rock in space. The diagram also shows that the force of gravity acting on that rock is strong and to the left.

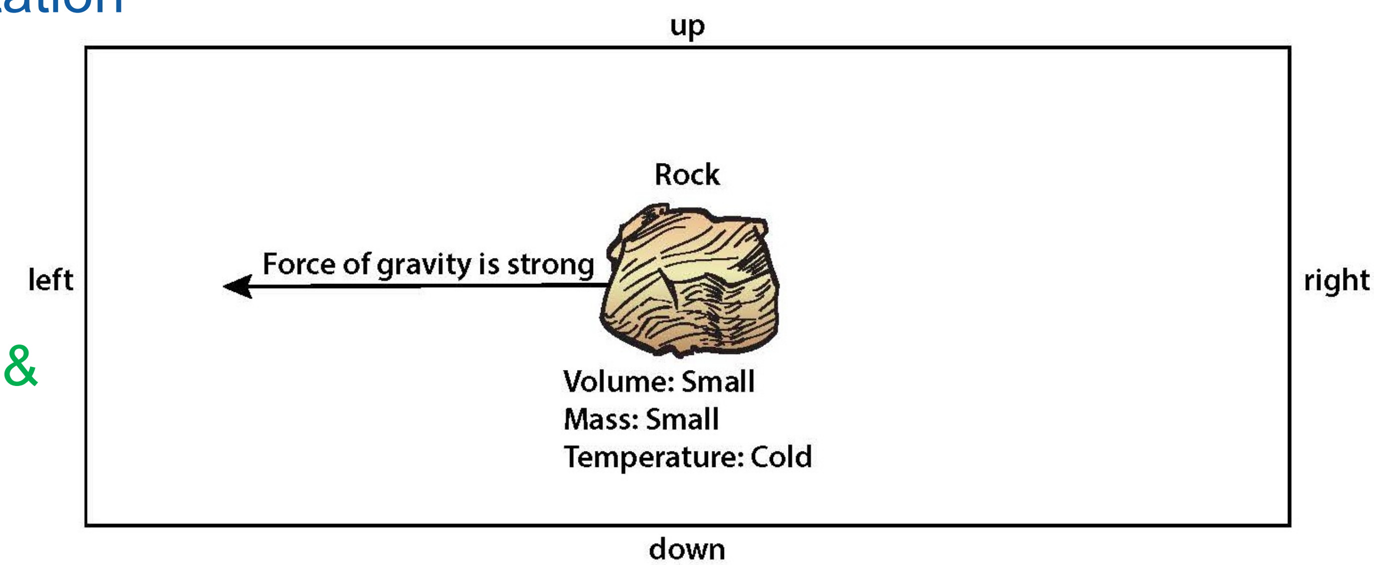
A news reporter wants to explain what is happening with the rock to her audience. She claims that the reason this force is strong and to the left is that there is another object to the left, and that object has a large mass.

Could this claim explain why the force of gravity is strong and to the left? What is your evidence, and why does it support or go against her claim?

SEP: Argumentation

DCI: Attractive gravitational forces

CCC: Systems & system models



Sample Student Response:

Yes, that claim would explain why the force of gravity is strong and to the left. My evidence that there is an object to the left is that the force is to the left. Gravity is an attractive force between objects that have mass, so if the force is to the left, that means an object must be that way. My evidence that the other object has a large mass is that the force is strong. Gravity is stronger when masses are larger, and since the mass of the rock is small, the force must be large because the other object has a large mass.

Lessons Learned/Revisited

- Multiple item parts to elicit response to all 3D of PE
- Very rarely use multiple choice
- Models work best when students have a starting point and *very* clear instructions on what to include. Also:
  - Improve or correct an existing model
  - Add captions to models
- Choices:
  - Choose the next step in an investigation and explain why
  - Choose the best two pieces of evidence and explain why
- Scaffolds:
  - Use language cues
  - Ask clearly for each aspect you are assessing

Contact Information

- Maia Binding
  - mbinding@berkeley.edu
  - (510) 643-3429

- Project Website:
  - https://lawrencehallofscience.org/educators/cigna
  - Has two papers about the project, sample assessments coming soon