NGSS-Focused Summative Classroom Assessments of Three-Dimensional Learning

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SEPUP
Issue-Oriented Science

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Agenda

- Project introduction
- Experience and discuss 3 sample assessments
  - Earth
  - Physical
  - Life
- How to participate, if you are interested

Assessment 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 the assessments:** Work with teachers to obtain input and pilot assessments in their classrooms
- **Expert review:** Teachers, curriculum and assessment experts
- **Availability:** The items will be widely available for use and modification

Assessment Project Overview

- Lawrence Hall of Science Project, led by SEPUP
  - FOSS, LDG, and Research staff are also participating
- Two-year project, started January 2018
- 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.

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)
- Piloting with approximately 150 students
- Additional expert review

Earth Science

Earth Science
MS-ESS2-4: Earth's Systems

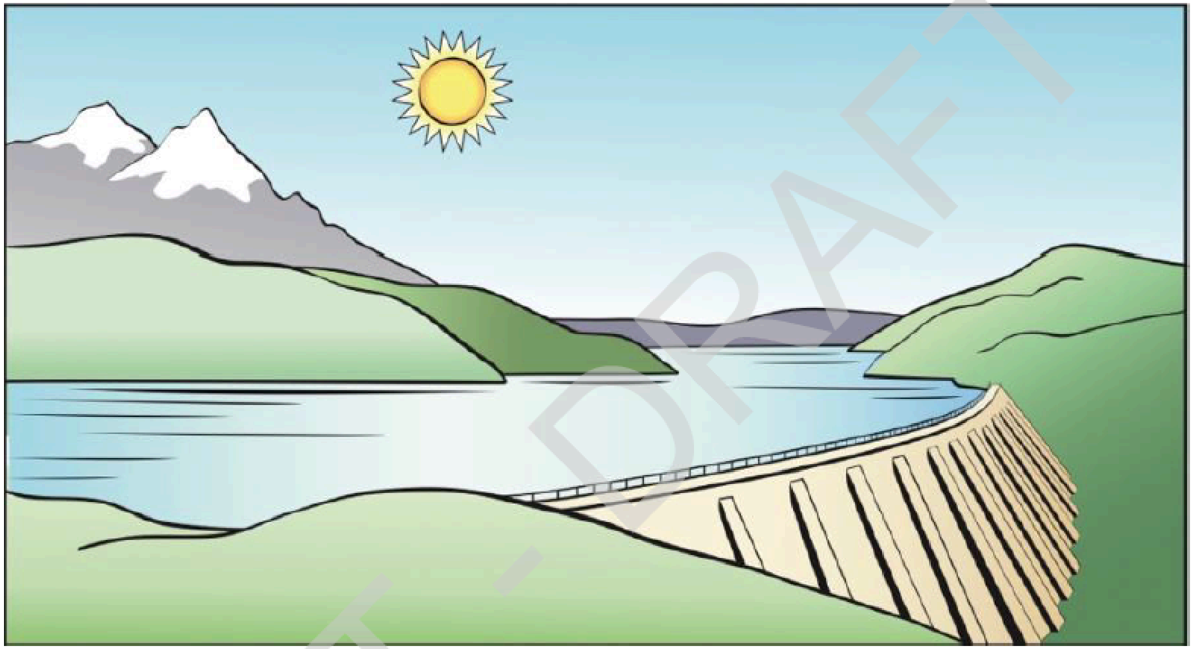
Students who demonstrate understanding can:

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.

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 lower elevation.



Sample Item: The picture above shows a reservoir, a large body of water built by people, in the mountains.

a. Most of the water in the reservoir comes from the snow at the top of the mountains. How does the water get from being snow in the mountains to the reservoir? Add arrows and captions to the diagram to show your ideas.

b. The water of the snow in the mountains used to be in the oceans far away. How did the water in the ocean end up in these mountains? Create a model with arrows and captions to show your ideas.

Discussion & brief sharing

- Where do you see the three dimensions in the item?
- What challenges might students encounter?
- What supports might students need to engage in three-dimensional sensemaking as they respond?
- What kinds of answers might you expect?

Life Science

Life Science
MS-LS2-3: Ecosystems, Interactions, and Dynamics

Students who demonstrate understanding can:

MS-LS2-3. **Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the 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

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 phenomena.

Disciplinary Core Ideas

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Crosscutting Concepts

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system.

Connections to Nature of Science

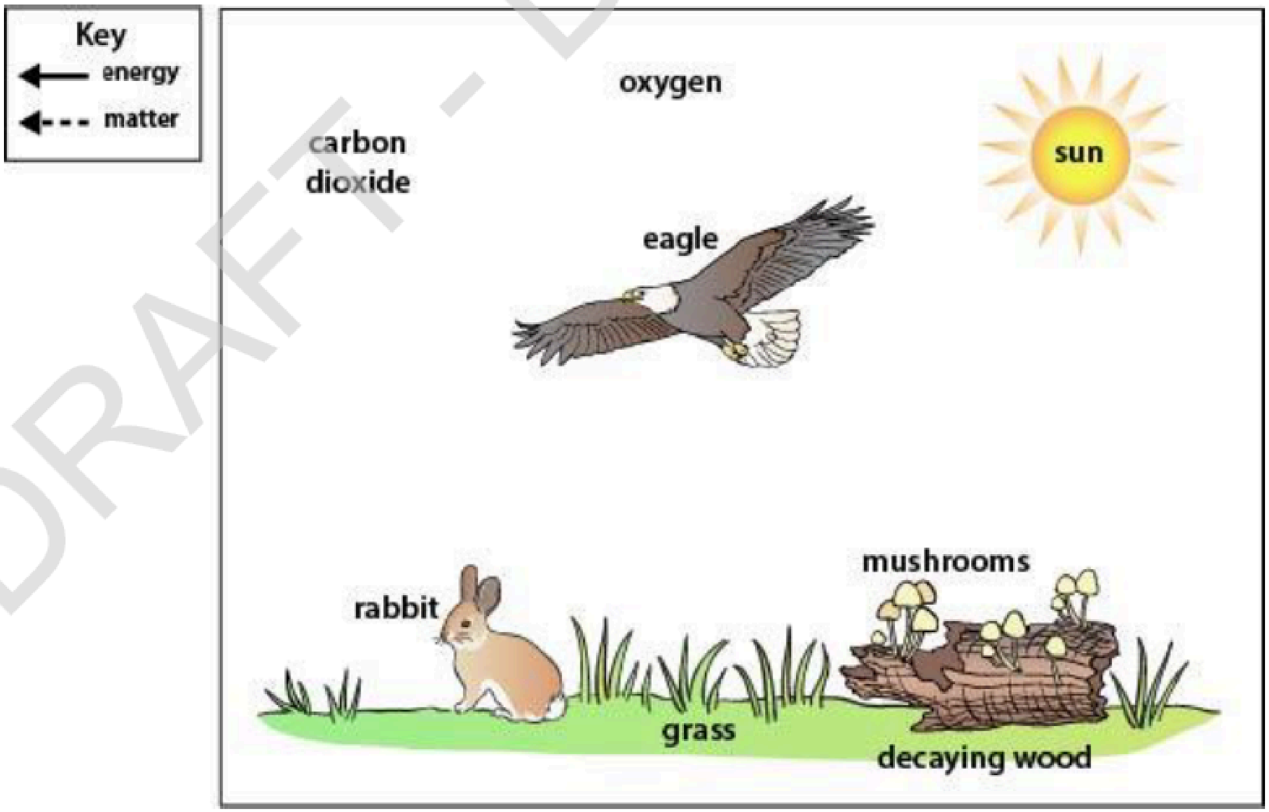
Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Learning Performance: Develop a model to show the flow of energy and the cycling of matter in an ecosystem.

Sample item: Add to the diagram below to develop a model of an ecosystem by doing each of the following:

a. Draw solid arrows (→) to show where energy flows in this ecosystem.

b. Draw dashed arrows (- - ->) to show where matter cycles in this ecosystem.



Discussion & brief sharing

- Where do you see the three dimensions in the item?
- What challenges might students encounter?
- What supports might students need to engage in three-dimensional sensemaking as they respond?
- What kinds of answers might you expect?

Physical Science

Physical Science
MS-PS3-5: Energy

Students who demonstrate understanding can:

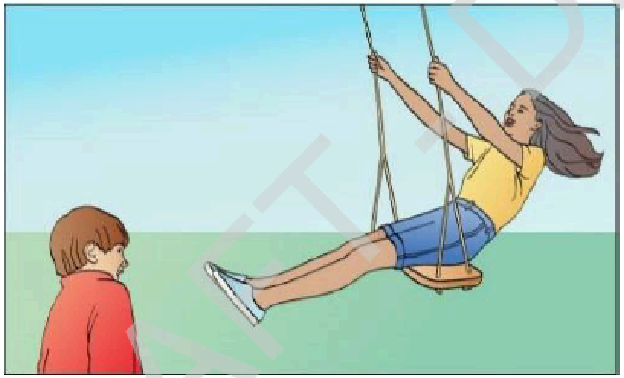
MS-PS3-5. **Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.** [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

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
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on 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 worlds. • Construct, use, 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. - - - - - - - - ***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	**PS3.B: Conservation of Energy and Energy Transfer** • When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Learning Performance: Students can present oral or written arguments to support or refute an explanation or model related to the energy transfers that must occur when the kinetic energy of an object changes.

Sample Item: Owen and Sophia were using the swings in the playground when they decided they wanted to see what affected how high a swing can rise. Sophia used a swing for three minutes before letting the swing stop on its own.



Owen used his cell phone to record Sophia on the swing. Later they analyzed the video and calculated the maximum speed and height of the swinging. Their results are shown in the table on the next page.

Sophia's results		
Time (min)	Maximum speed of swing (m/s)	Maximum height of swing (m)
0.5	3.1	0.5
1.0	4.0	0.8
1.5	4.8	1.1
2.0	5.0	1.2
2.5	5.2	1.3
3.0	5.2	1.4
3.5	4.0	0.8
4.0	2.0	0.2
4.5	0	0
5.0	0	0

After examining the data, Owen claimed that the kinetic energy of the swing affected how high the swing could rise. Construct an argument to support or refute Owen's claim. Make sure to include evidence of energy transformations and scientific reasoning in your response.

Discussion & brief sharing

- Where do you see the three dimensions in the item?
- What challenges might students encounter?
- What supports might students need to engage in three-dimensional sensemaking as they respond?
- What kinds of answers might you expect?

Sample answer

- I agree with Owen's claim that the kinetic energy of the swing affects how high the swing can rise. The evidence for this claim is based on the data from the table. The faster the swing, the higher it went. For example, when the swing went 3.1 m/s it rose to 0.5 m. Then as the swing went faster to 4.0 m/s, it increased to 1.1 m. Finally, when the swing got to its fastest speed at 5.2 m/s, it got to its highest height of 1.4m. This steady increase in height as the speed increases means that the speed was likely to be the cause of the change in height. Based on what I know about energy transformation, this makes sense because the kinetic energy of the faster swing was transformed into a higher potential energy as the swing went up in the air. The greater the kinetic energy, the more energy available to transform into potential energy (height) of the swing.

Sample draft scoring guide

Level	Description			
	Claim	Evidence	Reasoning	Aspects related to Item
Level 4 Complete and correct	The student's claim is clear and relevant.	The student's evidence supports the claim, is accurate and sufficient, AND student evaluates the strength of the evidence in supporting the claim.	The student's reasoning is appropriate, logically connected to the claim, and sufficient.	The response makes the connection between potential energy and kinetic energy changes during a swing. The response relates kinetic energy to speed. The response points out that the data support the connection between increased speed, increased K.E., increased P.E., and increased height.
Level 3 Almost there	The student's claim is relevant but incomplete.	The student's evidence is relevant, accurate, and sufficient.	The student's reasoning is appropriate and logically connected to the claim BUT is not sufficient.	The response relates P.E. changes to K.E. changes and points out that the data support the connection between increased speed and increased height. BUT the response doesn't clearly connect the speed and height with K.E. and P.E..
Level 2 On the way	The student's claim seems relevant but is unclear.	The student's evidence is relevant BUT is incomplete and/or contains inaccuracies.	The student's reasoning is scientific BUT is incomplete or not logically connected to the claim.	The response points out that the data support the connection between increased speed and increased height. BUT the response doesn't connect speed and height with K.E. and P.E..
Level 1 Getting started	The student's claim is irrelevant.	The student's evidence is irrelevant or does not support the claim.	The student's reasoning is nonscientific, does not logically support the claim, or does not connect the claim to the evidence.	The response does not use relevant evidence.
Level 0	The student provided no claim.	The student provided no evidence.	The student provided no reasoning.	
x	The student had no opportunity to respond.	The student had no opportunity to respond.	The student had no opportunity to respond.	

Questions so far

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Research Study

Purpose

To develop high-quality assessments to monitor students' progress towards understanding the Next Generation Science Standards (NGSS).

Who can participate?

Teachers currently teaching the NGSS in your middle school science classroom at a public or private school. Additionally, your principal or district must agree that we can conduct research in your classroom.

Interested in participating?

Please contact us!

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