NGSS Assessments: How will we know they are learning?

Presented by: Pam O’Brien
The new science standards...

Kitchen Tools & Techniques (Practices)

Basic Ingredients (Core Ideas)

Preparing a Meal (Three dimensional Learning)

Vegetables, Herbs, Spices, & Seasonings (Crosscutting Concepts)
Essential Question

How can I create three dimensional assessments to guide my instruction and collect evidence to monitor my students progress?
How does a pinball machine use energy to move the steel ball?
#1 Start with the standards

Performance Expectation

- States what the students must be able to demonstrate

Is this PE task something we can assess?

How do I get my students prepared to perform this task?
#2 Unpack the three dimensions

DCI - What will my students have to know?

PS3.A: Definition of Energy
• A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C Relationship Between Energy and Forces
• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

Key Vocabulary? What is interesting about this?
## DCI Progressions

<table>
<thead>
<tr>
<th>Category</th>
<th>K-2</th>
<th>3-5</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS3.A Definitions of energy</td>
<td>N/A</td>
<td>Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.</td>
<td>Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.</td>
<td>The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).</td>
</tr>
<tr>
<td>PS3.C Relationship between energy and forces</td>
<td>Bigger pushes and pulls cause bigger changes in an object's motion or shape.</td>
<td>When objects collide, contact forces transfer energy so as to change the objects' motions.</td>
<td>When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them.</td>
<td>Fields contain energy that depends on the arrangement of the objects in the field.</td>
</tr>
</tbody>
</table>
#2 Unpack the three dimensions

**CCC -- How the students should observe or think about the content.**

**System and System Models:**
- A system is an organized group of related objects or components.
- Models can be used for understanding the behavior of systems.

**What might this look like?**
#2 Unpack the three dimensions

SEP - What the students do

Developing and Using Models

• Use and construct models as helpful tools for representing ideas and explanations.

What might this look like?
My students must do...

My students must think about...

My students will discover...

Develop and use models.

Use and construct models as helpful tools for representing ideas and explanations.

Examples:
- Diagrams
- Drawings
- Physical Replicas
- Mathematical Representations
- Analogies
- Computer Simulations

PS3.A: Definition of Energy
- A system of objects may also contain stored (potential) energy, depending on their relative positions.

PS3.C: Relationship Between Energy and Forces
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
#3 Read the Evidence Statements

Purpose: To guide the development of
• three dimensional instructional activities
• three dimensional assessments

MS-PS3-2

1. Components of the model
   a. To make sense of a given phenomenon involving two objects interacting at a distance, students develop a model in which they identify the relevant components, including:
      i. A system of two stationary objects that interact.
      ii. Forces (electric, magnetic, or gravitational) through which the two objects interact.
      iii. Distance between the two objects.
      iv. Potential energy.

2. Relationships
   a. In the model, students identify and describe relationships between components, including:
      i. When two objects interact at a distance, each one exerts a force on the other that can cause energy to be transferred to or from an object.
      ii. As the relative position of two objects (neutral, charged, magnetic) changes, the potential energy of the system (associated with interactions via electric, magnetic, and gravitational forces) changes (e.g., when a ball is raised, energy is stored in the gravitational interaction between the Earth and the ball).

3. Connections
   a. Students use the model to provide a causal account for the idea that the amount of potential energy in a system of objects changes when the distance between stationary objects interacting in the system changes because:
      i. A force has to be applied to move two attracting objects farther apart, transferring energy to the system.
      ii. A force has to be applied to move two repelling objects closer together, transferring energy to the system.
#4 Develop a Summative Assessment

Recommendation from BOTA (Board on Testing and Assessment)

Design assessment tasks that include the three dimensions.

Tasks must

- Engage students in a science and engineering practice.
- Elicit students thinking about disciplinary core ideas and cross cutting concepts
**Summative Project**

**Balloon Car**

**PBL Entry Document**

Build and Learn Toy Company manufactures educational toys that are fun and entertaining. They are looking for a toy car product design that can be sold as a you build-it car kit. Research from the marketing team shows that certain attributes appeal to kids and would potentially improve sales. Balloons, always popular and fun, will provide the force needed to accelerate the toy. The construction of the toy should be easy to build and use simple everyday materials. The balloon-powered car should move fast, go a long distance, and look really cool.

You will be part of a team of experts who will provide different perspectives on the design and construction of the balloon-powered car. These experts include a Project Manager, a Mechanical Engineer, an Automotive Designer, and a System Operator. Your team will make a prototype design sketch and create an initial material list. Then your team will build and test the prototype, redesigning and testing as necessary to meet the criteria.

For your prototype to be considered for review, you must provide a poster that includes the original sketch and specifies all changes due to redesign. Identify at least three components of the prototype and explain how each one:

- shows a relationship between force, mass, and acceleration.
- demonstrates the effect of balanced/unbalanced forces on an object.
- shows a relationship between force, mass, and acceleration.

An instruction manual must accompany the prototype that contains:

1. An accurate material list.
2. Instructions for building the car – a series of ordered steps.
3. How to operate the car.
4. A data log of test results.
5. Designs and presentations that do not meet these requirements will not be accepted for consideration.

You will present your product design and other required items to a panel of representatives from the Build and Learn Toy Company. Your presentation is limited to 10 minutes. In that time, you are responsible for showing how redesigning relates to balanced/unbalanced forces and relationships between force, mass, and acceleration. Be enthusiastic so you can sway the representative to select your design. Addition consideration will be given to the team that demonstrates a way to easily modify design. Additional consideration will be given to the team that demonstrates a way to easily modify design. Addition consideration will be given to the team that demonstrates a way to easily modify design.
# Rubric for a Problem/Project-Based Learning Challenge

**Name:** Balloon Car  
**Date:**

## Rubric

<table>
<thead>
<tr>
<th>Points Awarded</th>
<th>Expert (4)</th>
<th>Competent (3)</th>
<th>Beginner (2)</th>
<th>Novice (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identification of Problem and Constraints</strong></td>
<td>Clearly defines the problem in real-world context and identifies the criteria in the solution. Meets time limit for presentation.</td>
<td>Defines the problem and the criteria within the context presented.</td>
<td>Identifies the problem and does not address the criteria.</td>
<td>Problem is not clearly identified and/or few criteria are addressed.</td>
</tr>
<tr>
<td><strong>Solution, Prototype, or Plan</strong></td>
<td>Prototype demonstration includes relationship between three design components and changing acceleration or balanced/unbalanced forces. Meets time limit for presentation.</td>
<td>Prototype is complete. Presentation of prototype missing 1-2 requirements. Meets time limit for presentation.</td>
<td>Prototype is complete. Presentation of prototype missing requirements. Slightly over or under time limit.</td>
<td>Prototype is incomplete. Presentation of prototype missing requirements. Well over or under time limit.</td>
</tr>
<tr>
<td><strong>Design Details</strong></td>
<td>Poster is neat and complete. Reasoning for redesigned elements is clearly stated during the poster presentation.</td>
<td>Poster is neat and nearly complete. Reasoning for redesigned elements is present but not thorough.</td>
<td>Poster is missing 1-2 pieces of information.</td>
<td>Poster is sloppy and missing more than two pieces of information.</td>
</tr>
<tr>
<td><strong>Poster</strong></td>
<td>Manual is neat and complete. Reasoning is thorough, and data from test results are used as evidence to support design changes during the presentation.</td>
<td>Manual is complete. Reasoning is clear but not thorough.</td>
<td>Manual missing 1-2 pieces of information.</td>
<td>Manual missing more than two pieces of information.</td>
</tr>
<tr>
<td><strong>Scientific Content shows depth in understanding and is applicable to the solution of the problem.</strong></td>
<td>Presentation of prototype, instruction manual, and design poster shows understanding of balanced/unbalanced forces and causes of acceleration change.</td>
<td>Presentation of prototype, instruction manual, and design poster shows understanding of balanced/unbalanced forces and causes of acceleration change.</td>
<td>Presentation of prototype, instruction manual, and design poster does not show an understanding of balanced/unbalanced forces and causes of acceleration change.</td>
<td>Presentation of prototype, instruction manual, and design does not address or discuss the effects of balanced/unbalanced forces or causes of acceleration change.</td>
</tr>
</tbody>
</table>
Sample Assessment

Scenario

In a pinball machine, a ball, usually steel, moves through a game board. The object of the game is to keep the ball in play to gain as many points as possible before the ball falls through the hole at the bottom. To begin the game, you pull back a lever with a spring and shoot the ball onto the board. Typically, the farther you pull back the spring, the farther and faster the ball goes. Also, there are pieces called flippers that you can manipulate to try to keep the ball from falling into the hole.

External Data

A

B

C

D
#5 Develop Formative Assessments

- Design three dimensional instructional activities
- Prepare your students to demonstrate the standard
- Formatively assess their progress as they complete various activities
Rubber Band Energy

Activity
1. Gather a few rubber bands, a ruler, goggles, and measuring tape. Put on the goggles.
2. Be careful to not aim at any person. Stretch the rubber band about 10 cm. Measure the stretch with the ruler. Let go of the rubber band.
3. Use the measuring tape to measure how far the rubber band traveled and record your results on the table.
4. Repeat steps 2 and 3, but stretch the rubber band to 15 cm.
5. Repeat steps 2 and 3, but stretch the rubber band even farther!

<table>
<thead>
<tr>
<th>Stretch (cm)</th>
<th>Distance Traveled (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cm</td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td></td>
</tr>
<tr>
<td>___ cm</td>
<td></td>
</tr>
</tbody>
</table>

6. What connection do you notice between stretching the rubber band and the distance it flew across the room?
**Scientific Investigation**

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**Explore**

**Potential Predictions**

The force of gravity can cause objects within a system to interact. The mass of the objects and distance between them are the variables that control how much gravitational potential energy is stored in the system.

Consider an apple hanging on a tree several meters above Earth’s surface. The apple and Earth make up a system. The apple stores potential energy because of its position above Earth’s surface. The apple has the “potential” to fall, so it has gravitational potential energy.

When the apple falls from the tree, its potential energy transforms into kinetic energy, causing it to fall faster and faster until it strikes the ground. A system’s energy equals its potential energy plus its kinetic energy and the total does not change as the apple falls. When the apple is still in the tree, the energy of the system is 100% potential. The moment it has fallen halfway down, the system’s energy is 50% potential and 50% kinetic. The moment just as the apple is about to strike the ground, the system’s energy is almost 100% kinetic.

**Procedure:**

Plan an investigation to explore potential energy by holding a ball above Earth’s surface and then dropping it from different heights.

**Question:**

**Hypothesis:**

**Materials:**

1 Bouncy ball
1 Meterstick
Crosscutting Concepts - Scoring Rubric

MS-PS Grade - Bundle 4: Potential and Kinetic Energy

Scope: Potential Energy

4) Systems & 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.

Artifact
Evaluate the student’s response to the following prompt.
“What were you able to model in your investigation? What did you learn about the system involving the earth and a falling object?” (Explore 1) “What did you learn about the system involving charged objects?” (Explore 2)

Novice: A student at the novice level is able only to describe the simple mechanics of their investigation.

Representative Novice Responses:
- We dropped a ball from different heights.
- We gave a charge to a balloon by rubbing it.

Emergent: A student at the emergent level can describe how their model relates to potential energy and the interactions within a system.

Representative Emergent Responses:
- We modeled the system of potential energy and how it changes. We dropped a ball from different heights and watched it bounce to see how potential energy changes.
- We modeled the system of electrical potential energy and how it changes. We rubbed a balloon more to give it more charge (potential energy) and observed how it attracted paper.

Proficient: A student is proficient if they can describe in detail how their investigation models the system of potential energy involving the earth and an object.

Representative Proficient Responses:
- We modeled the system of potential energy and the factors that affect that system. We dropped a ball from different heights and watched it bounce to see how potential energy changes. As we increased the height we dropped the ball from, we saw that it had more potential energy.
- We modeled the system of electric potential energy and the factors that affect that system. By rubbing the balloon more times with wool we gave it more potential energy and it could pick up paper from farther away.
Science & Engineering Practices - Scoring Rubric

MS-PS Grade - Bundle 4: Potential and Kinetic Energy

Scope: Potential Energy

2) Developing & Using Models

Develop a model to describe unobservable mechanisms.

Artifact
Evaluate the student’s response to the following prompt.
“Describe what you learned about potential energy from one activity. How did the activity provide information to help you reach this understanding?” (Explore 1, Explore 2)

N Novice

Novice: A student at the novice level is unable to offer a reasonable response.

Representative Novice Responses:
- I don’t know.
- We learned how potential energy changes.

E Emergent

Emergent: A student at the emergent level describes an activity or a conclusion about potential energy, but can’t relate them to each other.

Representative Emergent Responses:
- We saw that a ball bounces higher if you drop it from higher.
- We saw how if something has more potential energy, it can do more work.

P Proficient

Proficient: A student is proficient if they can describe a conclusion and connect it to the model they observed in class.

Representative Proficient Responses:
- We learned that the higher you lift an object, the more potential energy it has from the pull of gravity. We learned this by dropping a ball from higher and higher and watched how it bounced.
- We learned that the more electrical potential energy an object has, the more it can attract something. We learned this by rubbing a balloon with wool to give it an electric charge so it could pick up small pieces of paper. The more we rubbed the balloon, the more energy it had and it could pick up the paper from farther away.
Let's Take a Look