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Understanding energy: Primary students investigate the effects of energy

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Understanding Energy

Primary students investigate the effects of energy.

By Deepika Menon, Blake Shelby, and Christine Mattingly

Energy is a term often used in everyday language. Even young children associate energy with the food they eat, feeling tired after playing soccer, or when asked to turn the lights off to save light energy. However, they may not have the scientific conceptual understanding of energy at this age. Teaching energy and matter could be challenging at the K–2 level because they are abstract concepts. Nevertheless, developing a concrete understanding of energy at an early age is important for children in order to rationalize why we need energy from food or why wearing gloves helps keep our hands warmer.

The *Next Generation Science Standards* (*NGSS*) emphasize energy beginning as early as K–2 (NGSS Lead States 2013; see Connecting to the *NGSS* on p. 58). In this article, we share our success with implementing a 5E (Bybee 1997) inquiry-based energy lesson that engages K–2 students in energy flow in everyday life. Students observe events and the associated patterns and use these patterns to formulate their evidence-based explanations for energy transfer. Drawing from *NGSS* performance expectation K-PS2-1, we use the physical model of a ball rolling down a ramp set at different heights to illustrate the effects of motion and energy. The lesson presents ample opportunities to extend the activity through connections to the *Common Core State Standards for ELA*. Our main focus in the lesson is to build a strong foundation and excitement toward the abstract concepts of energy and matter at an early age, in order for these concepts to further develop during later grade levels.

Engage

We began our lesson by introducing the game "Simon Says" and giving directions for students to respond to different motions as they were called out. For instance, "Simon says clap your hands," or "Simon says hop on one foot." Students were reminded to stay in their spaces so that they did not bump into each other during "call outs." After students responded to the motions as they were called out, we asked how their bodies felt from the different motions and how they would feel if these motions were to be repeated again and again. Many students responded that they felt tired or would be tired if they were to continuously jump for a long period of time. Some students responded that they needed energy to continuously perform these activities.

When asked to compare the energy they might need to clap their hands for a few minutes versus to jump, many students responded that they would need more energy to jump. At this point, we asked students what they thought energy was. While many students struggled to provide answers, some students did associate energy to eating food, having seen their parents eat protein bars or drink energy drinks. It was at this point when we emphasized that energy is not something we can see but that we can see the effects of energy in a variety of phenomena. We further shared that energy is not an object or a thing that is visible, but we feel its effects. For example, we get energy from food we eat to do our daily work. With that notion introduced, we moved on to our exploration activity to help students see or feel the effects of energy when dropping a ball from different heights.

Exploration

CAUTION We first discussed important safety rules for handling materials before, during, and after (cleanup) the investigation as a class. For example, students were instructed not to play or throw balls at each other, and that the PVC pipe ramp setup would only be handled by the teacher. To ensure students' safety, all materials were carefully chosen, such as Styrofoam balls and plastic cups. Students were also reminded to be respectful of their classmates while taking turns to perform the investigation. Then, the class was divided into two groups of seven to eight students, spread apart at the two opposite ends of the classroom so that the balls could move freely without interruption. (Note: If necessary, form additional groups with fewer students to work in the hallway.) Working in small groups also benefits students with special needs by fostering interaction between students with varied learning abilities, thus providing comfort with the sharing of ideas with each other.

Each group had a PVC pipe to use as a ramp, two similar-sized balls, plastic cups, and a data worksheet for each student. We chose PVC pipes because their curvature would help keep the ball rolling without falling to the sides before hitting the ground. Teachers could also use other materials (e.g., books) as ramps and raise the ramp to different heights. We used plastic cups to change the heights.

The students were asked to make predictions on how far the ball would travel from the top of the ramp through different heights (that is, one-cup height, two-cup height, and three-cup height). We provided a printed hand measurement (Figure 1) for students to refer to while making predictions about the distance the ball would travel down the ramp. We chose handprints as the unit of measurement because the students had just completed a lesson where they measured different items with handprints. We provided one common handprint to provide consistency for all students to use during exploration. We asked, "How far do you think the ball will go from the one-cup height?" and "How many handprints will the ball travel?" We further prompted students to think, "What will happen when you increase the height to two cups tall and three cups tall?"

After students wrote their predictions on their data sheet (Table 1, p. 56), we set up the ramp to the one-cup height and asked a student to drop the ball down the ramp. Students observed that the ball moved freely to the ground and stopped at a certain distance. They counted the number of handprints to measure the distance the ball traveled and recorded it on their data charts. Three trials were conducted for each fixed height, for which students took turns. We talked about the importance of having more than one trial for each height in order to have fair data. Next, the investigation was repeated

FIGURE 1.

Hand-print measurement.

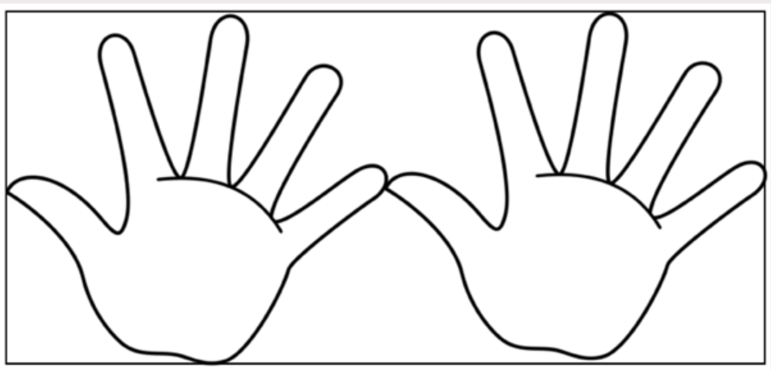


TABLE 1.

Data sheet.

Ramp Data Collection				
Height of Ramp	**Prediction** (number of hands)	**Trial #1** (number of hands)	**Trial #2** (number of hands)	**Trial #3** (number of hands)
1 cup tall				
2 cups tall				
3 cups tall				

with the ramp at its two-cup height and three-cup height. Students observed that the ball traveled farther away on the ground as the height of the ramp increased.

Explanation

We asked students to compare their predictions to their data. Many students noticed that their predictions were different than the data they collected. We asked, "What do you notice about the distance the ball traveled at each height?" The students said that the ball traveled farthest at the three-cup height and traveled the least distance at the one-cup height. Students justified their findings with evidence-based explanations, indicating that there were more handprints for the three-cup height than the two-cup height and the one-cup height. Students also indicated that the one-cup height had the least number of handprints. All of the students came to a conclusion that as the height increased, the ball traveled a greater distance.

We challenged students to think in terms of energy by asking, "In which situation did the ball have more energy: when dropped from the one-cup height, two-cup height, or three-cup height?" How can you tell?" Most of the students explained that the ball possessed more energy when dropped from the three-cup height because it traveled a greater distance compared to other heights. It was an "aha moment" for us to see the students connecting energy with the ball rolling from different heights. At this point, we introduced the scientific terminology for energy, associating height with "potential energy" and associating movement or motion as "kinetic energy."

During discussions, it is important for teachers to point out that energy can be converted from one form to another. We used the example of the ball rolling down the ramp to explain to students that potential energy associated with height was converted to kinetic energy of the ball when moving. Teachers should explain that the ball has both potential and kinetic energy when moving down the ramp and that the ball has only kinetic energy when moving on the ground. Teachers may continue the discussion on potential and kinetic energy by providing real-world scenarios, such as a waterfall or water stored in dams.

PHOTOS COURTESY OF THE AUTHORS

The class releases balls down a ramp (left) and explores energy and motion using Newton's cradle (right).

Elaborate

We designed two activities to further extend students' understanding of conservation of energy and energy transfer. We began by placing one ball at rest (labelled Ball A) at the bottom of the PVC ramp (one-cup height). Students made predictions on what would happen when another ball rolled down the top of the ramp (labelled Ball B) with Ball A sitting still at the bottom of the ramp. Students said that Ball B (on top) will hit Ball A (at the bottom). We further asked, "What will happen to Ball A when hit by Ball B?" Some students immediately responded that Ball A would move, but many were unsure.

We had a discussion on what we should do next to find out, emphasizing that scientific investigations allow us to test our predictions, make observations, and formulate evidence-based explanations. Students noticed that Ball A, initially at rest, started to move when hit by Ball B. Some students made the connection that the energy from Ball B rolling down the ramp made Ball A move. We further explained that some of the energy from Ball B transferred to Ball A when they collided, which made Ball A gain energy and move. Our focus was to help students understand the energy of Ball B after it hit Ball A. Students realized that Ball B slowed down, stopped, and did not go as far as it had in the previous investigation when there was no interruption. After discussion, we explained that Ball B lost some of its energy when it hit Ball A, so it did not move as far.

The second activity addressed the concept of conservation of energy and energy transfer using Newton's Cradle, a set of five hanging balls attached to strings for support. We lifted one ball to a certain height and asked students to predict what would happen if the ball was released. We asked, "How many balls will move when two balls are released?" Students predicted that in both cases, all the other balls will move but the two balls will push the other balls harder. After trying, students were amazed to see that when they released one ball from a height, only one ball from the other side moved. Similarly, when two balls were released, only two balls from the other side moved. Students shared that two balls have more energy than one ball, so they could make two balls on the other side move, and that one ball only has the energy to move one ball. We further explained that the potential energy of the ball released from the height was converted into kinetic energy. The energy was transferred through the balls to the last ball in the row in order to move to the same height. Therefore, energy was conserved—it changed forms but was neither created nor destroyed.

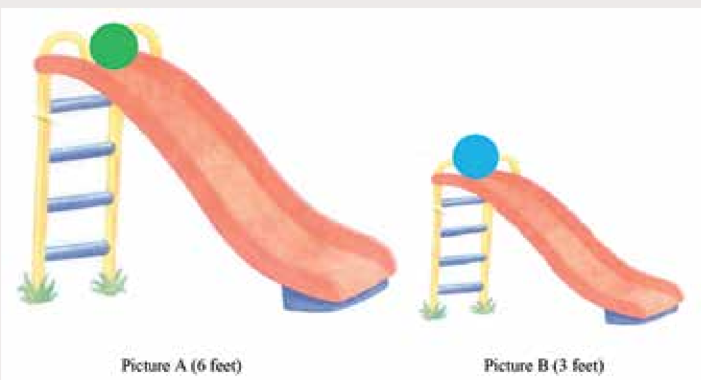
Evaluation

This lesson offered ample opportunities to formatively assess students' understanding on energy throughout the phases of this 5E lesson (see NSTA Connection for the assessment chart). For our summative evaluation, we had the whole class share their concluding remarks about what they learned about energy (Figure 2). We asked students to consider what would happen if we did the same ramp-and-ball activity with different objects, such as toy cars. We then challenged students by showing a picture of two playground slides with different heights, one with a red ball and the other with a green ball at the top. The slide with the red ball had a greater height than the slide with the green ball. Teachers can also use this assessment probe at the beginning of the lesson as a preassessment and again at the end of the lesson to assess students' understanding on energy (see NSTA Connection for answer key and rubrics). We asked students "Which ball would travel farther and Why?" All students responded that the red ball would travel farther and gave appropriate scientific explanations to support their answers.

FIGURE 2.

Summative evaluation.

The green and red balls are the same size. The green ball will start at the top of a 6-foot-tall slide and the blue ball will start at the top of a 3-foot-tall slide. Which ball will travel farther? Explain your choice.



Conclusion

For students to understand the complex conservation of energy principle—that is, energy is not created or destroyed but can be transformed to other forms—scaffolding may be required throughout grade levels. Careful planning of activities and simple investigations at an early age (K–2) would enable students to experience the effects of energy and lay a strong foundation to develop more complex understandings in later years. ■

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National Governors Association Center for Best Practices & Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common core state standards*. Washington, DC: NGAC and CCSSO.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.

NSTA Connection

Download the summative assessment answer key, rubric, and assessment chart at *www.nsta.org/SC1612*.

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

K-PS2-1 Motion and Stability: Forces and Interactions

www.nextgenscience.org/pe/k-ps2-1-motion-and-stability-forces-and-interactions

The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

Performance Expectations	**Connections to Classroom Activity** *Students:*
K-PS2-1. Plan and conduct an investigation to compare the effects of pushes on the motion of an object. K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed of an object.	• release a ball down a ramp to observe the motion of the ball, compare the motions of the ball when it is released from different heights, and compare the effects of motion in terms of energy. • collect and analyze data as the ball is released down the ramp from different heights and relate it to the distance travelled and relative energy possessed by the ball.
Science and Engineering Practices	
Planning and Carrying Out Investigations Analyzing and Interpreting Data	• work in groups to conduct scientific investigations relating ramp height to energy of the released ball. • compare “number of hands” in each trial to the distance traveled from different heights and relate that to relative ball’s energy.
Disciplinary Core Ideas	
PS2.B: Types of Interactions • When objects touch or collide, they push on one another and can change motion. PS3.B: Conservation of Energy and Energy Transfer • Energy is present whenever there are moving objects, sound, light, or heat.	• investigate one ball at rest colliding with another ball moving down the ramp, and observe, record, and interpret findings to make conclusions about transfer of energy from one ball to another. • investigate Newton’s Cradle to observe the motion of balls released from a certain height.
Crosscutting Concept	
Patterns	• note that as the height of the ramp increased, the distance of the ball traveled and its energy also increased.