**Lesson Research Proposal for 4th grade Energy**

For the lesson on November 8, 2016
Science Conference: “It’s Go Time: Seeing the future through the NEW NYS Science Learning Standards”
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1. **Title of the Lesson:** Patterns of change

2. **Brief Description of the lesson:** Students will continue making observations of changing objects. After completing observations of seven changing objects, students will articulate a pattern in how objects change before, during, and after an interaction.

3. **Research Theme:** Students will use science notebooks to record observations support the explanation that objects change during an interaction.

If students record their observations in their notebook, this will support them in explaining their observations to others. This data collection will allow them to compare their observations to previous observations, as well as generate a claim supported by evidence to answer the focus question.

Careful use of the board by the teacher can support students in several ways. The teacher can model what students should record in their notebook. Students will also be able to see how their ideas develop over the course of the lessons. Board writing will be used as a strategy to help make students’ learning visible and connect their initial words and ideas to science content.

4**. Goals of the Unit:**
Students will be able to:

a) Make observations to identify four forms of energy - sound, light, heat, and motion.
b) Make observations to provide evidence that sound, light, heat, and motion can move from place to place.
c) Make observations to provide evidence that sound, light, heat, and motion can be converted into other forms of energy.
d) Through observations provide evidence that electric currents can move energy from place to place.
e) Through observations provide evidence that electrical energy can be converted into other forms of energy.

5. **Goals of the lesson:**

a) Students will be able to record observations in their science notebooks of the changes in objects before, during, and after an interaction.
b) Students will be able to make a claim about how objects change before and after an interaction and support it with evidence from their observations of at least two objects.

6. **Relationship of the Unit to the Standards**

| Related **prior** learning standards | **Learning standards for this unit** | Related **later** learning standards |
|---|---|---|
| 3-PS2-2 Make observation and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. | 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. | 5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. |

7. **Background and Rationale:**

In previous lessons, these fourth grade students have learned to write in science notebooks using claims and evidence. They have been studying seeds and plants. This unit marks the beginning of their study of energy-related concepts.

The NGSS link to the *Framework for K-12 Science Education*, released in 2011 and used as the research basis for the new standards. A summary of the development of the *Framework*, as well as a link to the document can be found here:
http://www.nextgenscience.org/framework-k–12-science-education.

The standard guiding our lesson design incorporates the practice of *planning and carrying out investigations* (#3), which in this standard is specified with the language "Make observations to provide evidence that…". As noted in the framework, one purpose of "careful observation and description is [the] identification of features that need to be explained (p. 56)" This is applicable in our lesson because we are focused on providing students with opportunities to make careful observations to provide evidence that energy can be transferred.

The *Framework* also identified four main core ideas that would be addressed in the physical sciences.
1. Matter and its interactions
2. Motion and Stability: Forces and Interactions

3. Energy
4. Waves and their Applications in Technologies for Information Transfer

The standard guiding this lesson further specifies physical standard 3.

As we learned from the background about energy in the *Framework*, energy is a quantity. Within a system, the total amount of energy is conserved unless energy enters or leaves the system. This means that for students to understand energy transfer, they need practice identifying the system and its boundaries. The *Framework* goes on to differentiate energy phenomena at the macro and microscopic levels. “At the macroscopic scale, energy manifests as motion, light, sound, electrical and magnetic fields, and thermal energy (p. 121).” Since these manifestations match the energy types indicated in the standards, we interpret the standard to mean that we should not be expecting fourth grade students to think about energy at the microscopic scale. This is further supported by the fact that for students to understand energy at the microscopic scale, they would need to have a particle model for matter. The standards themselves do not suggest this model would be taught until fifth grade. Furthermore, we have no indication that these students have yet developed a robust particle model.

8. **Research and Kyouzai kenkyuu**

We consulted multiple resources in creating our lesson. One influential resource was a text edited by Jeffrey Nordine titled, Teaching Energy Across the Sciences K-12. This resource identified “Five Big Ideas about energy” (p. 13):

1. All energy is fundamentally the same, and it can be manifested in different phenomena that are often referred to as different “forms” or “types”.
2. Energy can be transformed/converted from one form/type to another.
3. Energy can be transferred between systems and objects.
4. Energy is conserved. It is never created or destroyed, only transformed/converted or transferred.
5. Energy is dissipated in all macroscopic (involving more than just a few particles) processes.

While our goal was not to have students name these in our unit, we understand that these ideas, if developed well, could help students use energy as a concept to make connections across phenomena in the life, earth, and physical sciences.

As pointed out in the reading, we make observations about the conservation of energy all the time, even if we don’t notice it. For example, we’d be surprised if we ordered coffee and it got warmer as we drank it (Nordine, 2016). By the time our students get their first formal exposure to the energy concept in fourth grade (and in this unit), they have been forming their own intuitions about energy over the 10 years of their lives.

In 1983, Michael Watts published a study that documented six basic models of students' "homegrown" conceptions about energy. Here are the six models documented by Watts:

1. Energy is mainly associated with human beings.
2. Some objects "have energy", others "need" it.
3. Energy is dormant within some objects or substances and can be released by a trigger.
4. Energy is identified by overt displays, and the display itself is actually called energy.
5. Energy is a by-product of some situation and is relatively short-lived.
6. Energy is a very general kind of fuel, more or less restricted to technical devices and not essential to all processes.
7. Energy is some sort of physical fluid that is transferred in certain processes.

We anticipate hearing ideas like these among our students and our research lesson is aimed at trying to identify them. These ideas contrast with the big ideas, but in order to help students move toward the big ideas in their learning, we have to know what they are currently thinking.

Energy describes the physical interactions in systems and energy ideas help explain what is happening across all kinds of systems. We learned that the classic definition of energy as "the ability to do work" is limited. This is because when we calculate work as force times distance, we have to very carefully define the system. (And notice that these ideas aren't yet well developed for most 4th graders, so we can't really use them to teach kids about energy.) As crazy at it seems, since defining energy is so hard, the NGSS actually recommends not doing it in the early grades. Instead, we're going to help students associate energy with motion and that sound, light, heat, and electricity can move energy from one place to another. If we can help students notice a change in the energy of a system, that must mean that energy was transferred to the system or from the system. (We highly recommend you read Nordine - he makes a lot of sense.) Note, however, that we will not be emphasizing conservation yet.

We also consulted examples of energy units, including resources found on the internet. We noticed that some resources emphasized students' identifying types of energy transfers in their daily lives. However, these resources did not focus on students making observations or gathering evidence of change.

We consulted older energy units as well as new ones. We found multiple examples of energy transfer and have used them to design the stations to help our students make observations.

In our planning, we spent a lot of time talking about our standard: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. Given that this research lesson will only be the second one in the unit, we really wanted to focus on the practice component of the standard: "Make observations to provide evidence...".

We have also been influenced by 3-act-tasks in mathematics: https://gfletchy.com/3-act-lessons/ and http://blog.mrmeyer.com/2011/the-three-acts-of-a-mathematical-story/. Dan Meyer's ideas influenced the way we presented the opening in this lesson and tried to connect the idea of noticing phenomena and wondering about them to connect to the observation structure we established for the lesson.

9. **Unit Plan**

| **Lesson** | **Learning Goals and tasks** |
|---|---|
| 1 | **Focus Questions: How do objects change during an interaction?**<br>-First watch hand boiler video - jot some things down that they noticed and wondered on sticky notes<br>-One notice per sticky note<br>-One wonder per sticky note<br>-"As a class let's quickly fill in the chart"<br>-Have them sort their sticky notes - before, interaction, after, later<br>*Watch a second time<br>-Set up directions<br>-Explain the chart/table (pre-made)<br>-Do three stations and complete chart<br><br>-Report out what they noticed and record it on chart paper |
| 2 | **Research Lesson:**<br>**Focus Questions: How do objects change during an interaction?**<br>Launch:<br>5 min opening and refocusing - revisit their notes from yesterday<br><br>Stations:<br>20 minutes - station investigation<br>*notebooks will be in their spots and glue down will already be in place<br>Students will then investigate each station item and record their observations in the table.<br><br>Closing:<br>10 minutes - Students will find a pattern in their data from the table (small table discussion may be used or turn and talk) after they will fill in their claim and evidences table.<br>10 minutes - share/conclude (whole class) |
| 3 | Emphasize the types of energy present in the observations made in lessons 1 & 2 |

| | |
|---|---|
| 4 | Understand that the observations from lesson 1 & 2 indicate that energy moved from place to place and energy convert. |
| 5 | How can we use our observations to understand how electrical energy is converted to other forms of energy? |

10. **Design of the Unit and Lesson**

This unit has been carefully designed to focus on all three components of the standard. In particular, we've designed the two opening lessons to focus heavily on the scientific practice of making observations so that these observations lead further discussion about energy change. As reflected in the background, we're having to shift the focus away from a beginning with identification of energy forms and toward making observations of changing systems.

This unit has also been designed to leverage students' developing skill in science notebook writing, especially with recording observations and articulating patterns in their data. This is a higher-level reasoning expectation for students. We expect the students to notice patterns and use the language they have to articulate them. We anticipate that students might not use official scientific terminology when they first describe what they notice. Over the course of the unit, we will help them connect their ideas to the scientific terminology associated with energy and energy transfer.

This unit has also been designed to maximize the engagement of students in learning. We carefully considered the affordances of each object for helping students notice energy transfer. We selected objects that demonstrated the range of energy transfers articulated in the standard. We also selected objects that would permit students more direct contact (where possible) for exploration. For example, we only had one radiometer and incandescent light bulb, thus we made this a station students would come to in small groups. On the other hand, we had plenty of toys, so we gave each student one to explore. We are also promoting access to the content by focusing our attention on students' language, rather than expecting them to already use scientific terminology. Our observation sheet, while structured, is open to having students use a range of ideas to identify their thinking. Further, the objects we've selected for the lesson allow students to repeat their exploration as needed to fully record the change during the interaction.

This unit treats the students as capable learners of science. We are presenting them with a range of changes, some that are likely familiar and others that are new, and supporting them to make connections between the phenomena that are demonstrated with the objects.

The use of science notebooks is a critical tool for ongoing assessment of student thinking. Students are recording their observations, as well as their ideas about patterns, and supporting their claims. In this lesson, the teacher will be constantly checking on students' ideas because their thinking forms the basis of the discussion at the end of the lesson. Students' thinking will drive the comparison of what occurs at the various stations. The discussion will center on the students' ideas about energy, rather than the teacher's ideas.

11. **Research Lesson Plan**

In order to facilitate observer's note taking, the lesson plan is formatted differently and attached to this document.

12. **Evaluation**

How do the students make a claim and provide evidence to support how objects change during an interaction?

Will the students need more guidance in use of the objects or have we over structured?

How does the organizer help the students make clear scientific observations and record data? Is there enough space?

Do we have any students who refer back to the objects from Monday while making their claim?

Will students base their claim and evidence on the last object they observed?

How did students make connections between more than one object in their claim?

13. **Board Plan**

<u>Focus Questions</u>:
How do objects change during an interaction?

Opening video: hand boiler

Lesson 1:

| | Before | Interaction | After | Later |
|---|---|---|---|---|
| Newton's Cradle | | | | |
| Toy car | | | | |
| Radiometer | | | | |

Lesson 2:

| | Before | Interaction | After | Later |
|---|---|---|---|---|
| Light ball | | | | |
| Generator | | | | |
| Crank toy | | | | |

**Anticipated students' responses**

Hand boiler chart

| Notice | Wonder |
|---|---|
| I saw it go up the tube, hands held it, liquid from the bottom went to the top, it went up fast, some goes down as she lets go but not all of it. | Why did it take so long to go down but go up so fast? Why does it bubble? What makes it go up? What makes it bubble? Why are there loops and bubbles? Why is there a straw in it? Is there a straw in it? What is it made of? Is that water? What is the liquid - oil, water? Can you force it back down? Did you squeeze hard? |

Lesson 1:

| | Before | Interaction | After | Later |
|---|---|---|---|---|
| Newton's Cradle | Not moving still | Pull back the first ball and let go | Balls clack back and forth | They slow to a stop |
| Toy car | Not moving | Pull backwards<br>Pull back and let go | Goes forward<br>Goes fast<br>Moves<br>Zooms ahead | Stops<br>Hits something |
| Radiometer | Nothing moving<br>No light | Held light nearby | Squares spun | Squares slow down and stop |

Lesson 2:

| | Before | Interaction | After | Later |
|---|---|---|---|---|
| Light ball | Not lit<br>No sound | Ball hit floor<br>2 balls collided<br>Flick the ball | Lights | Light stopped |
| Generator | No sound<br>Not lit | Turn the crank | Lights<br>Loud sound | Light and sound stopped |
| Crank toy | Sitting<br>“Eating cheese” | Twist<br>Turn<br>Crank the knob | Bends down and flips over<br>Makes noise | Sitting again<br>Not moving |