

Learning a System of Practices of Science through Energy: A Fourth-Grade Case Study

Roger Tobin, Tufts University

Sara Lacy, TERC

Sally Crissman, TERC

Nick Haddad, TERC

Nathaniel Brown, Boston College

Gulsah Gurkan, Boston College

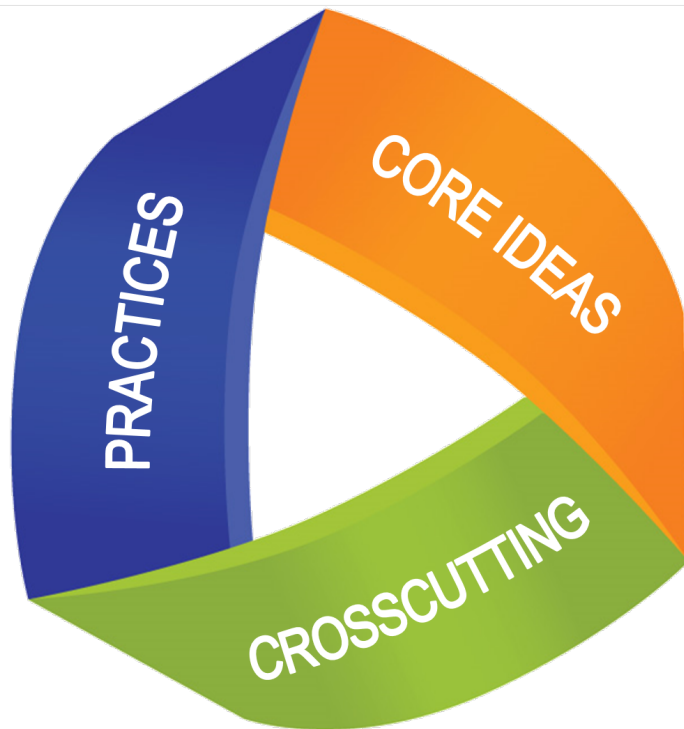
Courtney Castle, Boston College



“Three-dimensional” learning and teaching:

- Disciplinary core ideas
- Cross-cutting concepts
- Practices of science

Energy

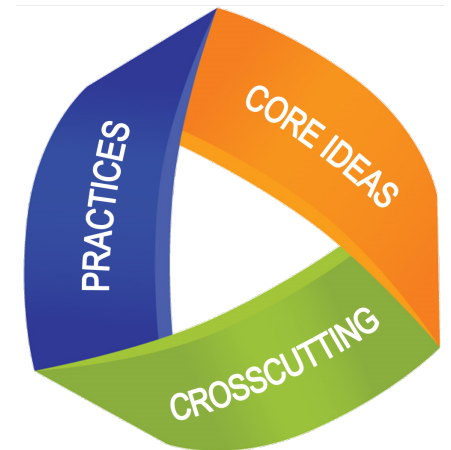


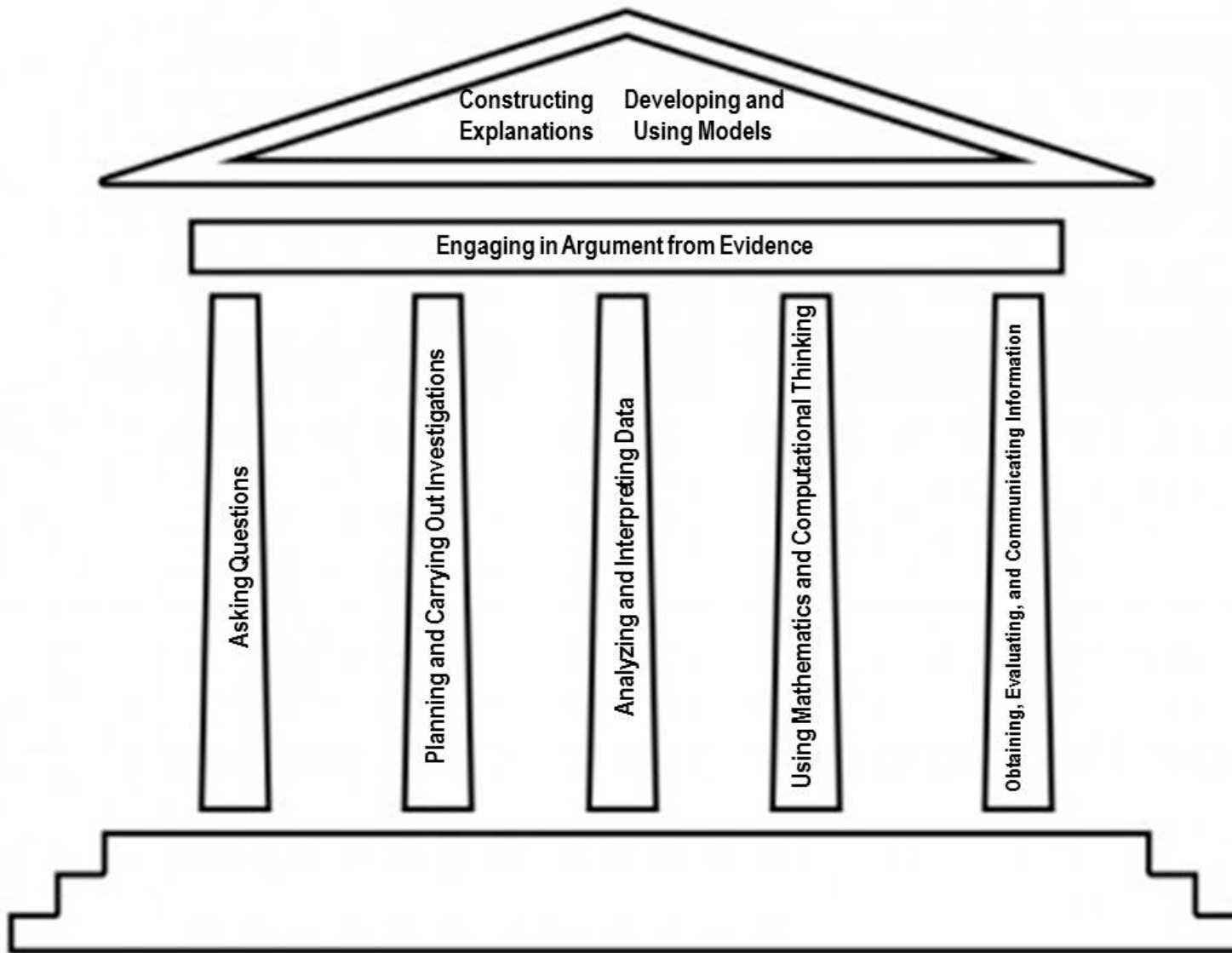
Science & Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Student engagement in practices of science

- What does it look like when elementary school students enact the practices of science?
- What features of the task and curriculum contribute to that enactment?





Pasley, J.D., Trygstad, P.J. & Banilower, E.R. (2016), *What does "Implementing the NGSS" mean? Operationalizing the science practices for K-12 classrooms*. Chapel Hill, NC: Horizon Research, Inc.



The Focus on Energy Program

- The Energy Tracking Lens
- Classroom Activities
- Representational Tools
- Teacher Workshop



The Energy Tracking

A consistent framework for using energy ideas to think about any scenario:

Part 1. Describe what you observe.

*Carrying out investigations
Analyzing and interpreting data.*

Part 2. Tell the energy story.

- System components?
- Form(s) of energy?
- Energy gains and losses?
- Energy transfers?
- Energy transformations?
- Where does the energy come from and where does the energy go?

*Constructing explanations.
Developing and using models.*

Use observations to support your energy story. *Arguing from evidence.*



Classroom Activities

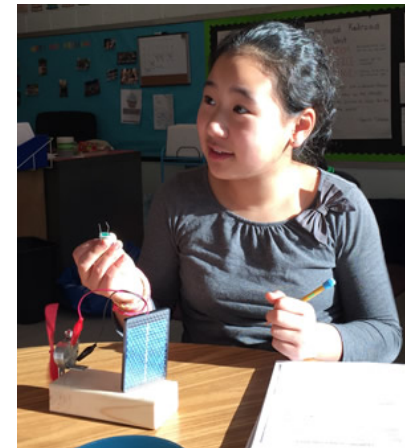
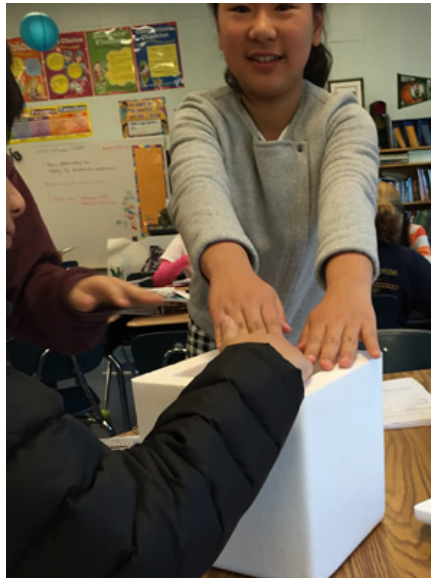
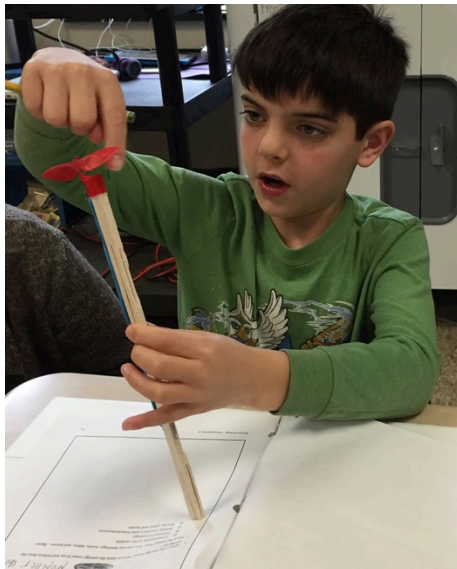
Motion/Elastic



Thermal



Electrical/Light



Through the activities, analyzed using the Energy Tracking Lens questions, the class collaboratively develops a model of energy:

A Model of Energy

- If it's moving it has energy.
- There are different kinds of energy.
 - elastic
 - motion (indicator)
- Speed is evidence of motion energy.
- There are different amounts of motion energy.
- When an object collides with another object the first object loses some of its energy.
- The total ^{amount} energy did not change.
- One ball transfers energy to another ball when there is a collision

Energy can transform.
~~motion~~ → elastic → motion

- If something is bent it has elastic energy.
- Energy doesn't disappear.
- Energy cubes can tell the energy story.
- Some motion transferred to the air
- Motion energy can transform into elastic energy

Noise Level Chart

- Silence is Golden**
Silence, No Talking, Testing, Individual Work
- Spy Talk**
Whispering - only one person can hear you
- Low Flow**
Partner or group work
- Formal Normal**
Regular speech, class participation

CATS, DOGS & BIRDS LOVES

PUNCTUATION Takes a Vacation

FOCUS on energy

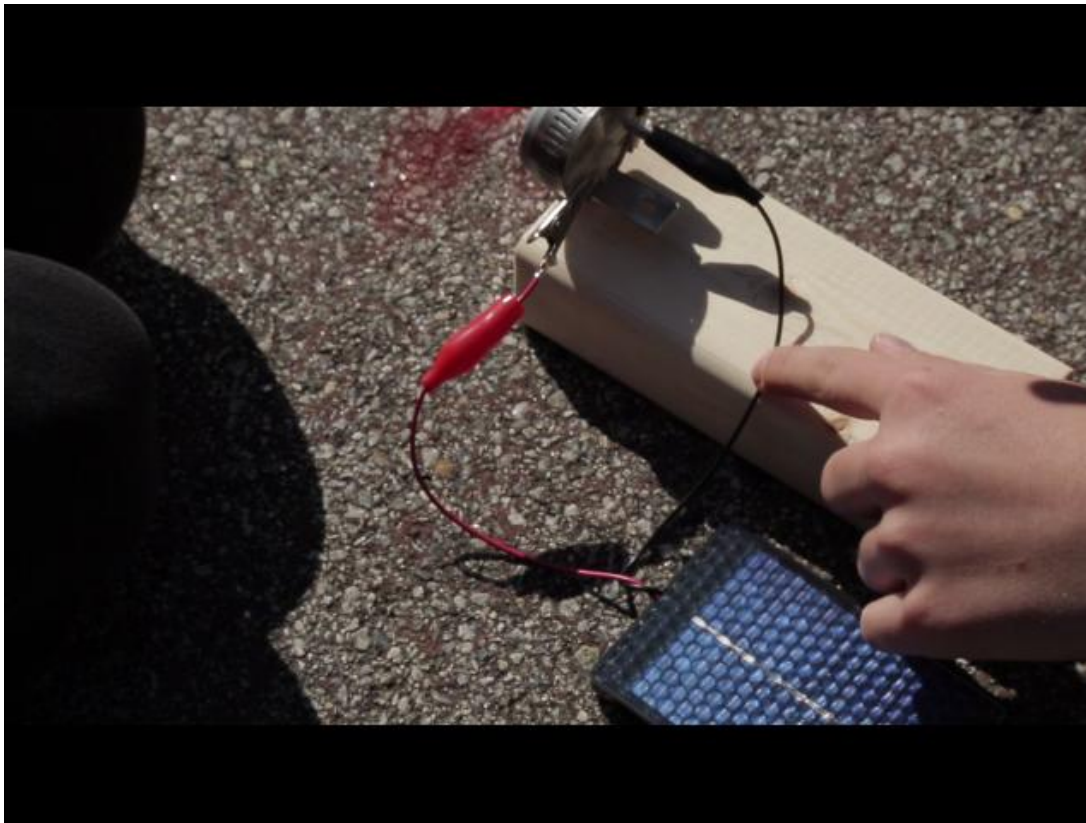
Summer Workshop for Teachers

- ◆ Learning about Energy
- ◆ Listening to Children's Ideas
- ◆ Planning to integrate energy into your curriculum

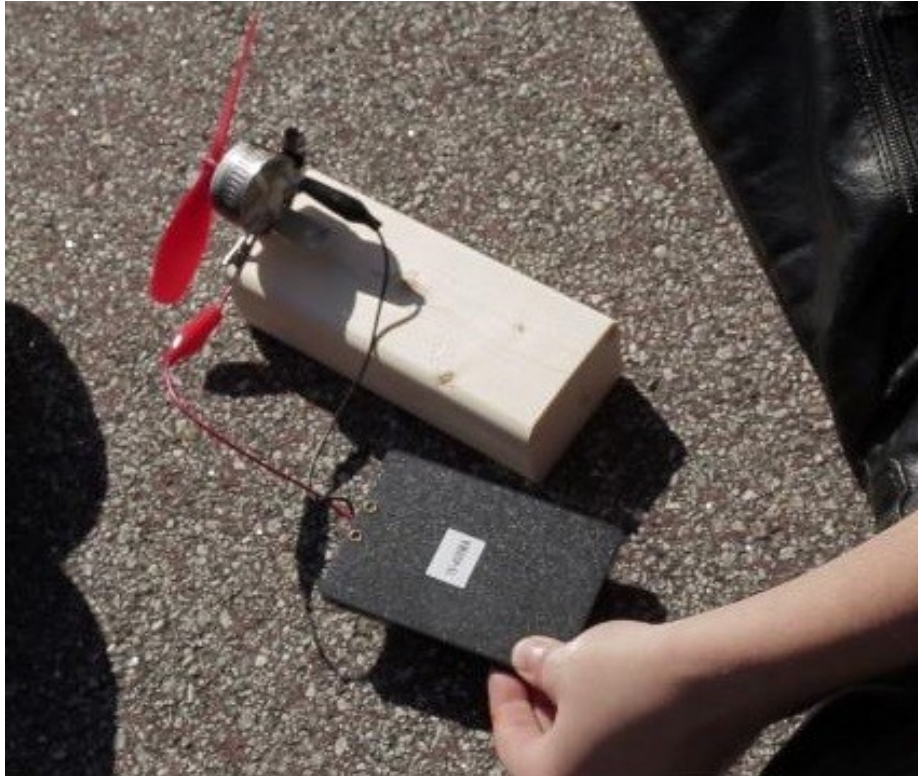


Case Study

- ◆ Fourth grade students, after school
- ◆ Completed Focus on Energy about 6 mo. previous
- ◆ Studying solar cell driving motor/propeller

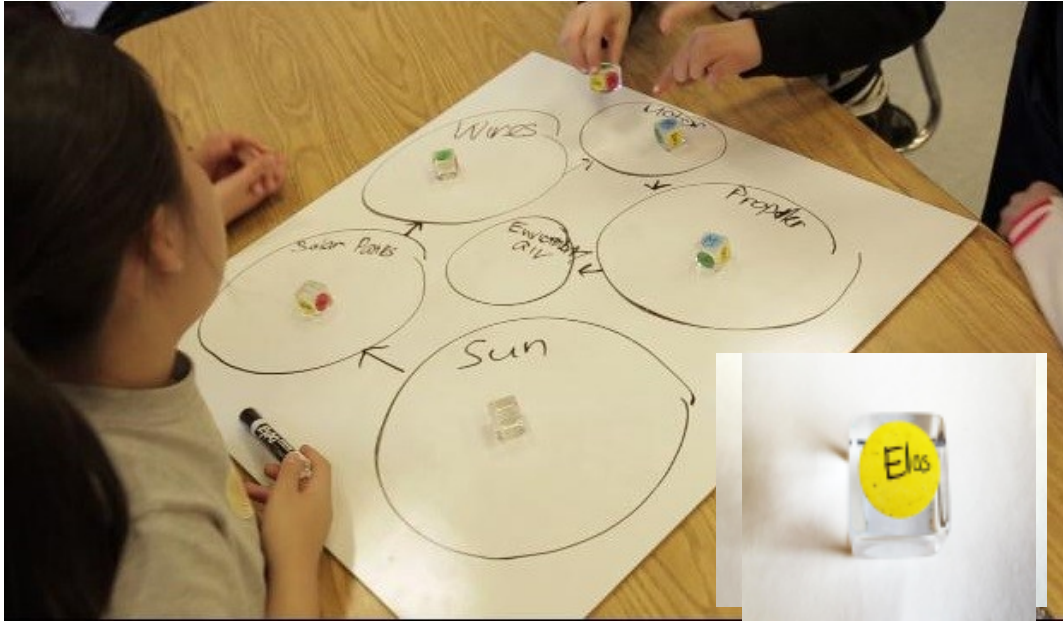


Is the solar energy light or heat?



*Carrying out investigations.
Analyzing and interpreting data.
Arguing from evidence.*

Representing the Energy Story: Energy Cubes



- Each cube represents a unit of energy.
- Circles represent objects.
- Symbol on top of cube represents form of energy.
- Moving cubes between circles represents energy transfer.
- Flipping cubes represents energy transformation.

Developing & using models / Creating explanations

Highly abstract representation of system, including invisible attributes (energy).

Students choose objects to represent, forms of energy, actions to perform.

Choices must be consistent with observations and with overall model of energy as developed in class.

Students use representation/model both to communicate and to construct explanation.

Telling the energy story with cubes



*Developing and using models.
Constructing explanations.
Arguing from evidence.*



What features of the task & curriculum contribute to the students' enactment of the practices of science?

Activity: Engaging, interesting, and accessible

Curriculum:

Coherent, carefully sequenced set of classroom activities.

Thoughtful decisions about what *not* to include.

Energy tracking lens questions provide consistent organizing structure.

Consistent theme of creating and using model of energy, individually and collectively.

Representations: Accessible, versatile, powerful.

Teacher preparation:

Week-long summer workshop + refresher meetings during school year.

Teachers experience curriculum/activities first as learners.

Emphasis on listening to, evaluating and responding to children's ideas.

Pedagogical approach focused on sense-making.



The **FOCUS** on team:
energy



**Sara Lacy
Sally Crissman
Nick Haddad**



Roger Tobin



**BOSTON
COLLEGE**

**Nathaniel Brown
Michael Russell
Gulsah Gurkan
Courtney Castle
Sebastian Moncaleano
Jane Heaney**



**Lane Seeley
Lezlie DeWater
Kara Gray
Rachel Scherr
Amy Robertson
Stamatis Vokos**

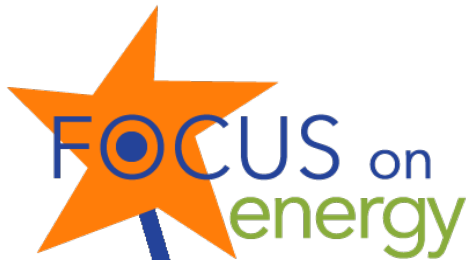


Jim Minstrell

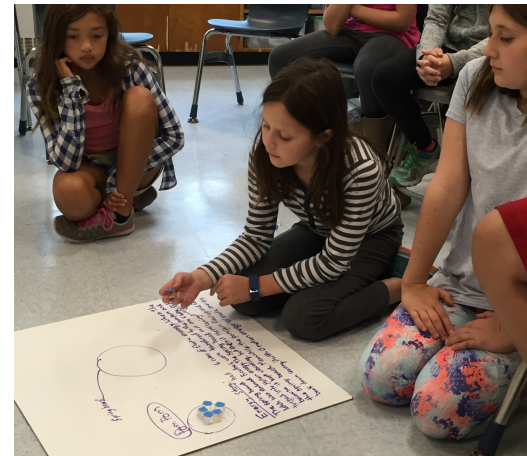
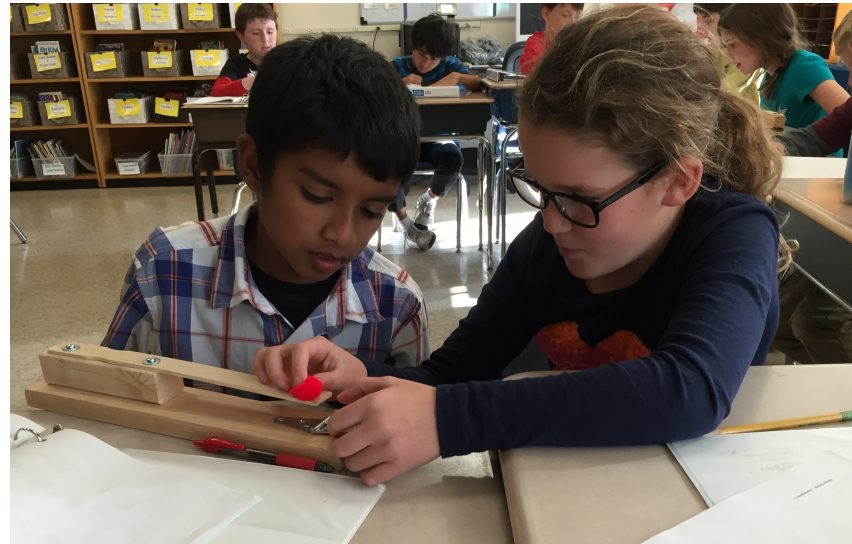
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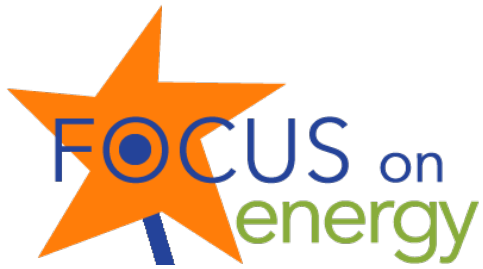


Draft paper available on request.



What's the Energy Story of the Paint Paddle and the Pompom?

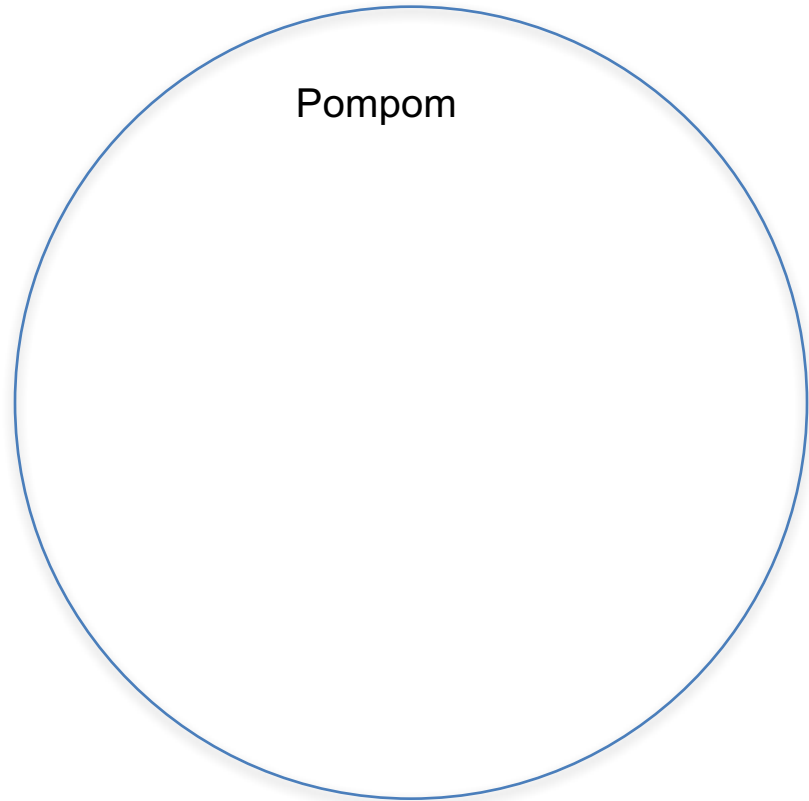
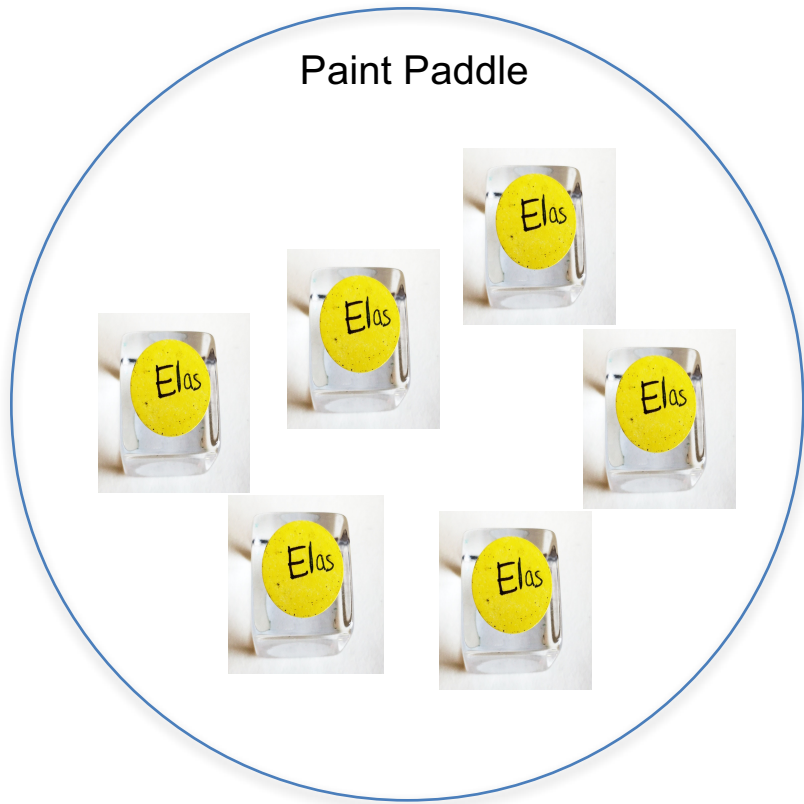


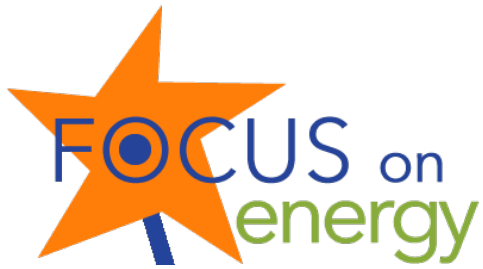


The paint paddle and pompom

Use energy cubes and Energy Tracking Lens questions.

- System Components?
- Form(s) of energy?
- Energy gains and losses?
- Energy transfers?
- Energy transformations?
- Where does the energy come from and where does the energy go?

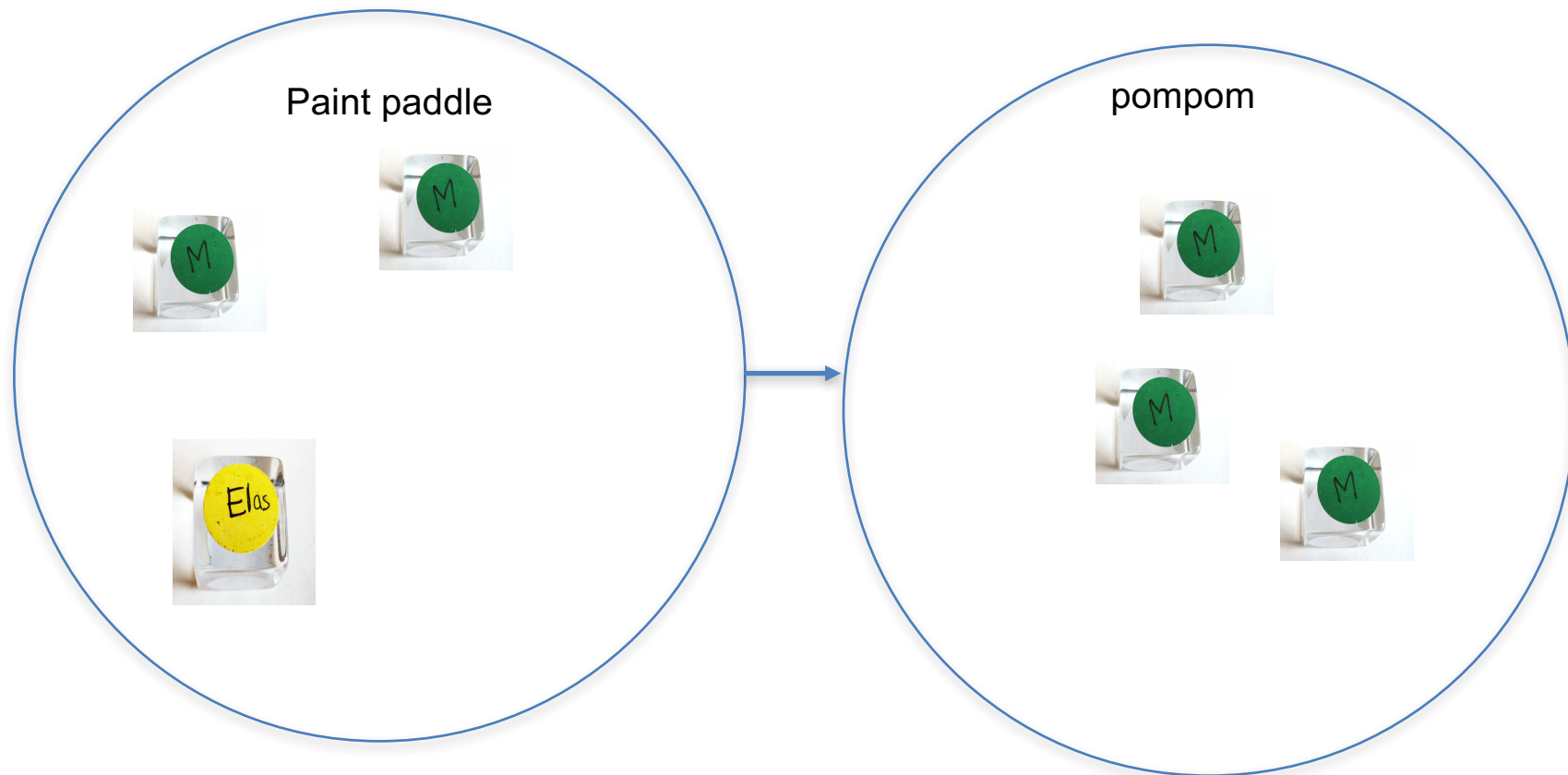


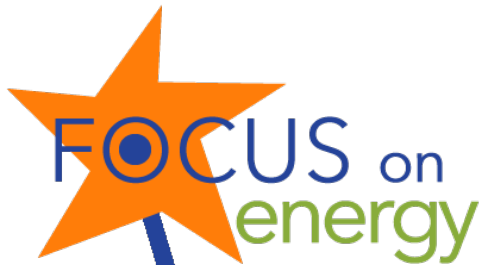


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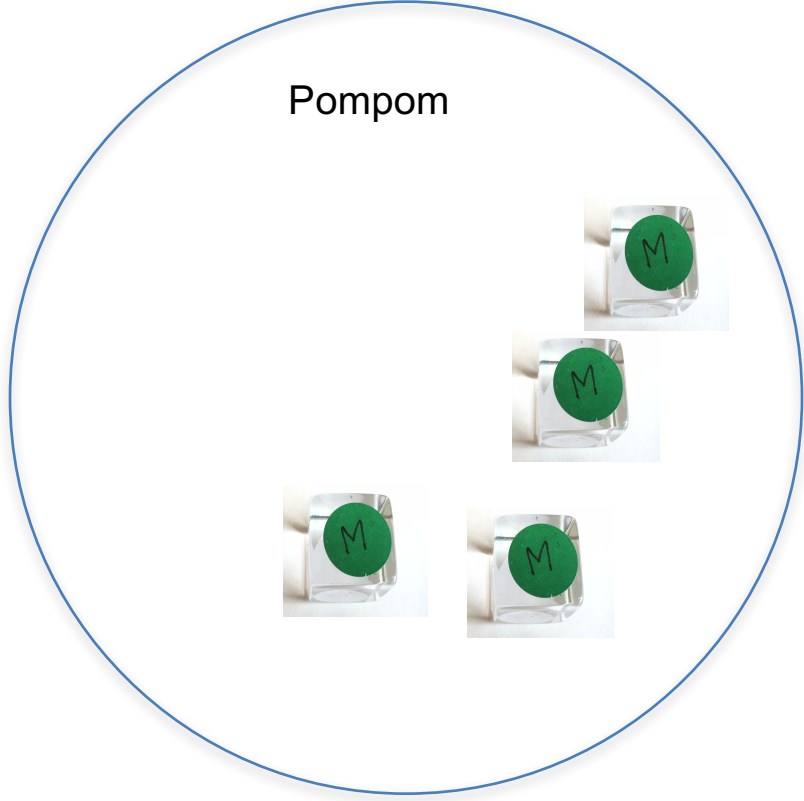
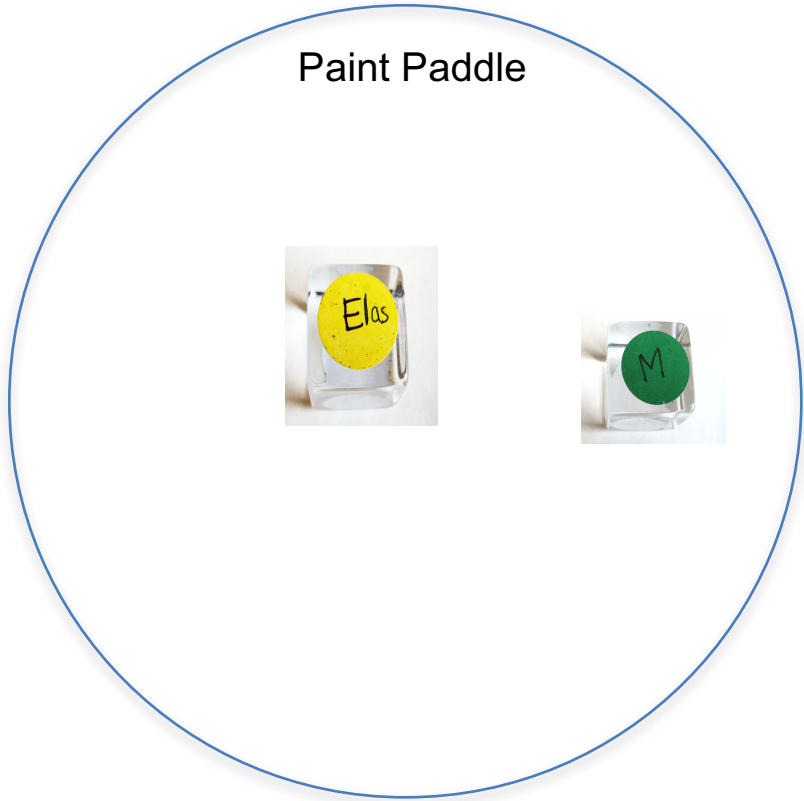




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Sparklz Pre-post assessment – preliminary results



Part 1. Describe changes you *observe* when you set Sparklz in motion. Use drawings, words, and/or arrows.

Part 2. Use drawings, words, and/or arrows to show how energy flows and changes when you set Sparklz in motion.

Use observations to support your claims.

- What components are involved?
- Form(s) of energy?
- Increases and decreases of amounts of energy?
- Energy transfers?
- Change of energy from one form to another?
- Where does the energy come from and where does the energy go?

Sparklz Pre-post assessment – preliminary results

PRE:

Sparklz

Name



Part 1. Describe changes you **observe** when you set Sparklz in motion. Use drawings, words, and/or arrows.

When Sparklz moves, sparkles are emitted from the "spinner." I also noticed that Sparklz zig-zags a little while she moves.



Part 2. Use drawings, words, and/or arrows to show how energy flows and changes when you set Sparklz in motion. Use observations to support your claims.

The way how I think sparklz's energy flows is that after you twist the key, the bottom of the key turns a big gear, which turns a smaller gear and that gear turns an even smaller gear, which turns the spinner and the wheels. I know this is probably true because I've built 2 robots before and after turning the key slowly a few times I saw how things works.

- What components are involved?
- Form(s) of energy?
- Increases and decreases of amounts of energy?
- Energy transfers?
- Change of energy from one form to another?
- Where does the energy come from and where does the energy go?

POST:

Sparklz



Part 1. Describe changes you **observe** when you set Sparklz in motion. Use drawings, words, and/or arrows.

- First the coil is loose and unwinded and with no elastic energy and then you wind the key and it coils up the coil and gives it elastic energy.



Part 2. Tell the Energy Story.

Use drawings, words, and/or arrows. Use observations to support your energy story.

- ① First you transfer motion energy to the key through winding it with your hand.
- ② The key transfers motion energy to the gears
- ③ The gears transfers motion energy and transforms elastic energy to the coil.
- ④ When the coil unwinds and you let go, the coil transfers motion energy to the other gears
- ⑤ The gears transfer motion energy to the scraper.
- ⑥ The scraper moves against the sandpaper and transforms into thermal energy with the sparks.
- ⑦ While the gears are moving the scraper they are also transferring motion energy to the wheel witch makes them wheel.
- ⑧ The coil runs out of energy and all the energy transfers stop.

- System Components?
- Form(s) of energy?
- Energy gains and losses?
- Energy transfers
- Energy transformations?
- Where does the energy come from and where does the energy go?

Sparklz Pre-post assessment – preliminary results

