

Energy Literacy: A Grade 4 Energy Unit Based on the NGSS* and Incorporating Environmental Education

National Science Teachers Association
2014 National Conference
Friday, April 4, 2014
9:30 – 10:30 AM

*Presenters: Patty O'Donnell
Micky McKinley
Hitchcock Center for the Environment
Amherst, Massachusetts*

Workshop Agenda:

- Who we are
- Background on development of our Energy Literacy unit
- NEEEA/U.S. EPA Sub-grant
- NGSS alignment
- Design of Unit
- Demonstration of Materials
- Hands-on Renewable Energy investigations
- How to access curriculum unit



Education for a Healthy Planet

About Us

The Hitchcock Center for the Environment is an independent nonprofit organization whose mission is to foster a greater awareness and understanding of our environment and to develop environmentally literate citizens.

Energy Is Electrifying! Curriculum is available for FREE download from the Hitchcock Center website: (see resources dropdown menu)

Contact Information:

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Hitchcock Center Grant: *Integrating Environmental Literacy and the Next Generation Science Standards**

- Funded by the New England Environmental Education Alliance (NEEEA) and the U.S. EPA Environmental Education Sub-Grants program.
- **Why we did this** – we were inspired by the environmental themes elucidated in the National Research Council (NRC) document – *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* – which guided the development of the NGSS.
- Provided an opportunity to demonstrate how environmental education can be used as an organizing principal to teach science concepts.
- We developed three environmental focused curriculum units for grades 3-5, aligned with the NGSS:
 - 3rd Grade - *The Pond Ecosystem*
 - 4th Grade - *Energy Is Electrifying!*
 - 5th Grade – *The Hydrosphere, Water and How We Use It*



*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

History of Hitchcock Centers Energy Literacy Programs

- We have had an ongoing commitment to Energy Literacy Education
- We provide Professional Development for Teachers of Grades 4, 5 & 6
- We model the curriculum in classrooms
- The NEEEA grant enable us to expand on this curriculum, incorporate the Next Generation Science Standards*, and make it available to a broader audience

Next Generation Science Standards*

- Based on the *Framework for K–12 Science Education*, released by the National Research Council (NRC) of the National Academy of Sciences, in July 2011
- Developed by (NRC), National Science Teachers Association, American Association for the Advancement of Science, and *Achieve*, a bipartisan, non-profit, education reform organization; with writers from 26 lead states
- NGSS released for adoption in April 2013
- Currently adopted by 11 states: California, Delaware, the District of Columbia, Illinois, Kansas, Kentucky, Maryland, Nevada, Rhode Island, Vermont, and Washington.
- Web address: <http://www.nextgenscience.org>

Massachusetts and the NGSS

- The MA Draft Revised Science and Technology/Engineering (STE) Standards, released December 2013, are based on the NGSS but are an adaptation of NGSS.
- Expected to move forward for adoption in the 2015-2016 school year
- For more information, refer to the Massachusetts Department of Elementary and Secondary Education website: www.doe.mass.edu/STEM/review.html

Overview of NGSS Format

- The Standards, by Grade Level and Discipline
- *Performance Expectations* – What is Assessed
- Foundation Boxes:
 - *Science and Engineering Practices* – How we teach, for example designing investigations and using models
 - *Disciplinary Core Ideas* – What we teach; the content
 - Physical Sciences (PS)
 - Life Sciences (LS)
 - Earth and Space Sciences (ESS)
 - Engineering, Technology and Applications of Science (ETS)
 - *Cross-cutting Concepts* – The Interdisciplinary Nature of Science, for example Patterns, Systems, Energy Flows and Cycles
- Connections to *Common Core State Standards*

NGSS* LAYOUT
Grade Level and Title

Performance Expectations

**Science and Engineering
Practices**

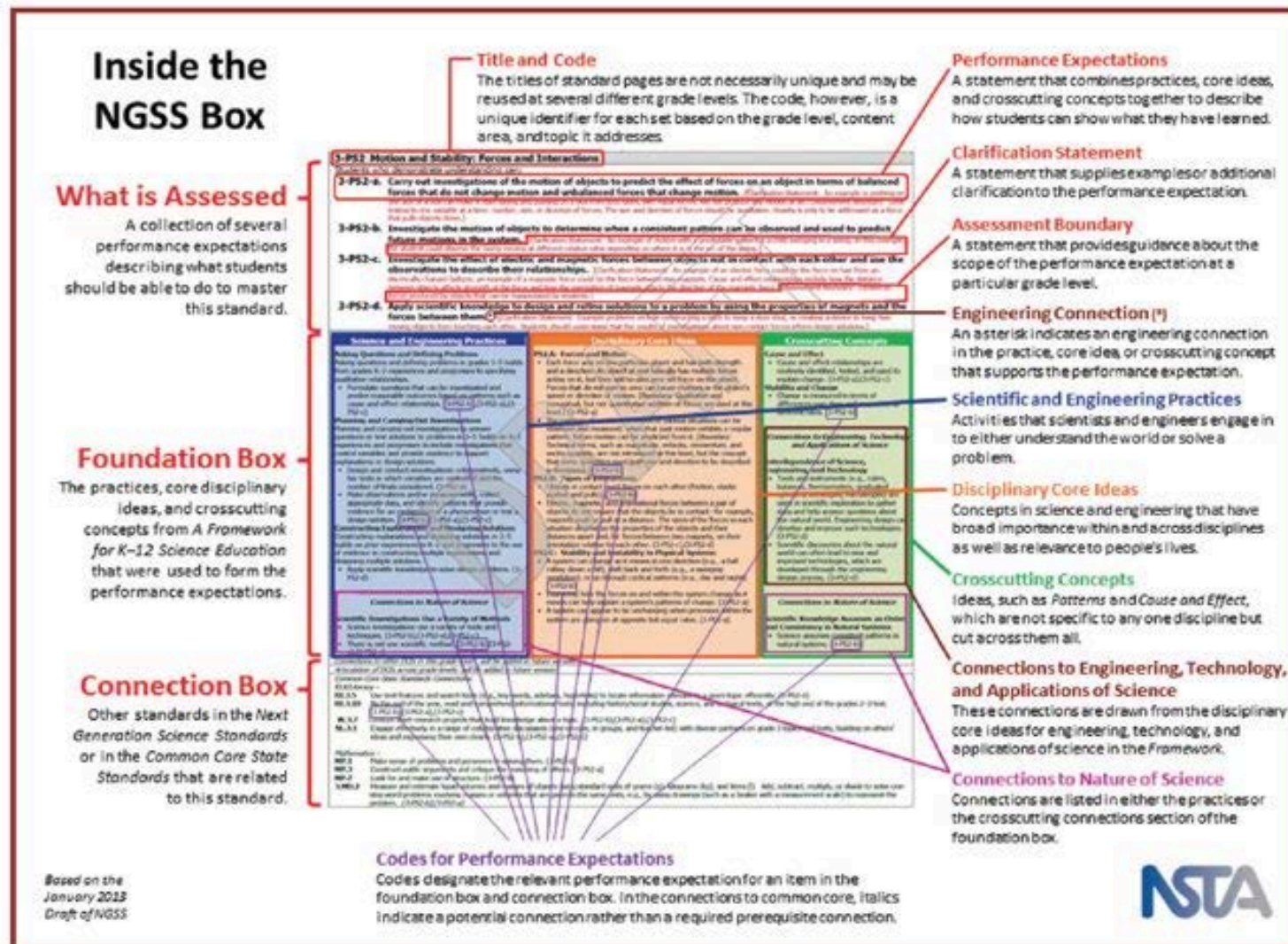
**Disciplinary
Core Ideas**

**Crosscutting
Concepts**

Connections to

- Other science disciplines at this grade level
- Other DCIs for older and younger students
- Common Core State Standards in Mathematics and Language Arts

Decoding the NGSS*



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Example:

Physical Science (PS) Standard - ENERGY – Grade 4

4.Energy

4.Energy		
Students who demonstrate understanding can:		
4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]		
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]		
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]		
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]		
4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]		
The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. <ul style="list-style-type: none"> Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3) Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. <ul style="list-style-type: none"> Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. <ul style="list-style-type: none"> Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) Apply scientific ideas to solve design problems. (4-PS3-4) Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. <ul style="list-style-type: none"> Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1) 	PS3.A: Definitions of Energy <ul style="list-style-type: none"> The faster a given object is moving, the more energy it possesses. (4-PS3-1) Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) PS3.B: Conservation of Energy and Energy Transfer <ul style="list-style-type: none"> Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3) Light also transfers energy from place to place. (4-PS3-2) Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4) PS3.C: Relationship Between Energy and Forces <ul style="list-style-type: none"> When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) PS3.D: Energy in Chemical Processes and Everyday Life <ul style="list-style-type: none"> The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) ESS3.A: Natural Resources <ul style="list-style-type: none"> Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1) ETS1.A: Defining Engineering Problems <ul style="list-style-type: none"> Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4) 	Cause and Effect <ul style="list-style-type: none"> Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) Energy and Matter <ul style="list-style-type: none"> Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2),(4-PS3-3),(4-PS3-4) <hr/> Connections to Engineering, Technology, and Applications of Science <hr/> Interdependence of Science, Engineering, and Technology <ul style="list-style-type: none"> Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1) Influence of Engineering, Technology, and Science on Society and the Natural World <ul style="list-style-type: none"> Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1) Engineers improve existing technologies or develop new ones. (4-PS3-4) <hr/> Connections to Nature of Science <hr/> Science is a Human Endeavor <ul style="list-style-type: none"> Most scientists and engineers work in teams. (4-PS3-4) Science affects everyday life. (4-PS3-4)
Connections to other DCIs in fourth grade: N/A		
Articulation of DCIs across grade-levels: K.PS2.B (4-PS3-3); K.ETS1.A (4-PS3-4); 2.ETS1.B (4-PS3-4); 3.PS2.A (4-PS3-3); 5.PS3.D (4-PS3-4); 5.LS1.C (4-PS3-4); 5.ESS3.C (4-ESS3-1); MS.PS2.A (4-PS3-3); MS.PS2.B (4-PS3-2); MS.PS3.A (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4); MS.PS3.B (4-PS3-2),(4-PS3-3),(4-PS3-4); MS.PS3.C (4-ESS3-1); MS.PS4.B (4-PS3-2); MS.ESS2.A (4-ESS3-1); MS.ESS3.A (4-ESS3-1); MS.ESS3.C (4-ESS3-1); MS.ESS3.D (4-ESS3-1); MS.ETS1.B (4-PS3-4); MS.ETS1.C (4-PS3-4)		
Common Core State Standards Connections:		
ELA/Literacy –		
RI.4.1		
Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)		
RI.4.3		
Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)		
RI.4.9		
Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS3-1)		
W.4.2		
Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)		
W.4.7		
Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)		
W.4.8		
Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)		
W.4.9		
Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1),(4-ESS3-1)		
Mathematics –		
MP.2		
Reason abstractly and quantitatively. (4-ESS3-1)		
MP.4		
Model with mathematics. (4-ESS3-1)		
4.OA.A.1		
Interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1)		
4.OA.A.3		
Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. (4-PS3-4)		

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled "Disciplinary Core Ideas" is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas*. Integrated and reprinted with permission from the National Academy of Sciences.

May 2013

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Energy Is Electrifying! Unit Format

- NGSS* Alignment is indicated at the beginning of the unit, and referenced in each Daily Plan
- Conceptual Flow for Student Understanding –
 - Background on Energy, Electricity and Electro-magnets
 - Forms of Energy
 - Fossil Fuel Energy Sources
 - Electrical Generation
 - Renewable Energy Sources
- Focus on Design Investigations (Correlate with NGSS ETS standards, Grade3-5)
 - Model Electro-magnet generators
 - Renewable Energy Investigations - Wind and Solar
- Additional Hands-On Activities in Unit:
 - Light Bulb Comparisons
 - Appliance Efficiency Comparisons
- Student Energy Chain Drawings – Illustrate their conceptual understanding of Energy Flow from the Sun, to the lights in the classroom

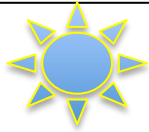


Unit Resources

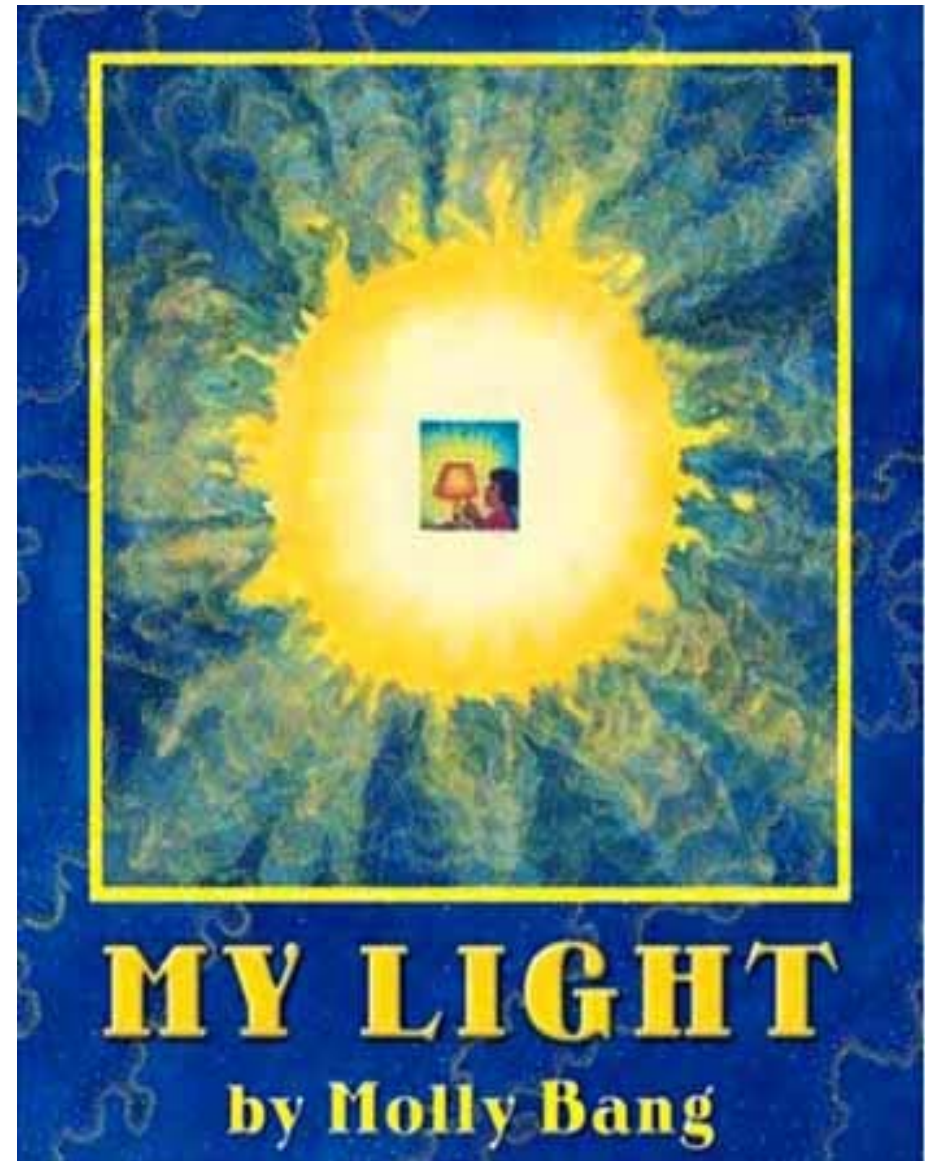
- Book *My Light*, by Molly Bang
- Northeast Sustainable Energy Association (NESEA). Available through the following website: http://energyteachers.org/project_detail.php?project_id=13
- National Energy Education Development Project (NEED) <http://www.need.org>
- NOVA Labs - PBS Learning Media – WGBH Boston
<http://www.pbs.org/wgbh/nova/labs/videos/>
- SWITCH ENERGY PROJECT <http://www.switchenergyproject.com>

...Plus many more cited in the unit

My Light

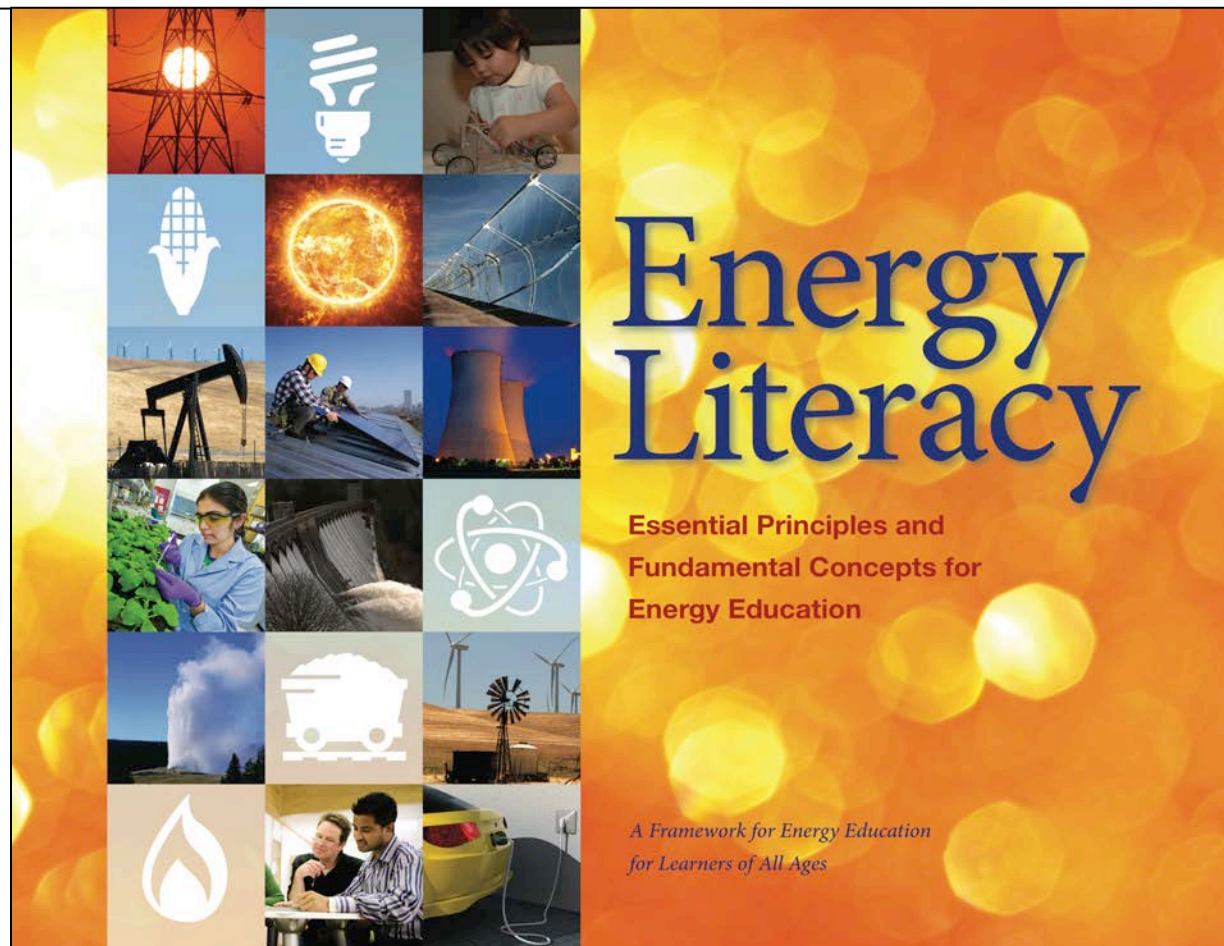


We reference *My Light* by Molly Bang often in this unit, and include it in our Professional Development bag of materials for teachers. We are inspired by the author's ability to make a seemingly overwhelming and complex energy concepts accessible. Ms. Bang brilliantly creates connections, and interconnections, all beginning with the singular source of energy for life on earth – our SUN.

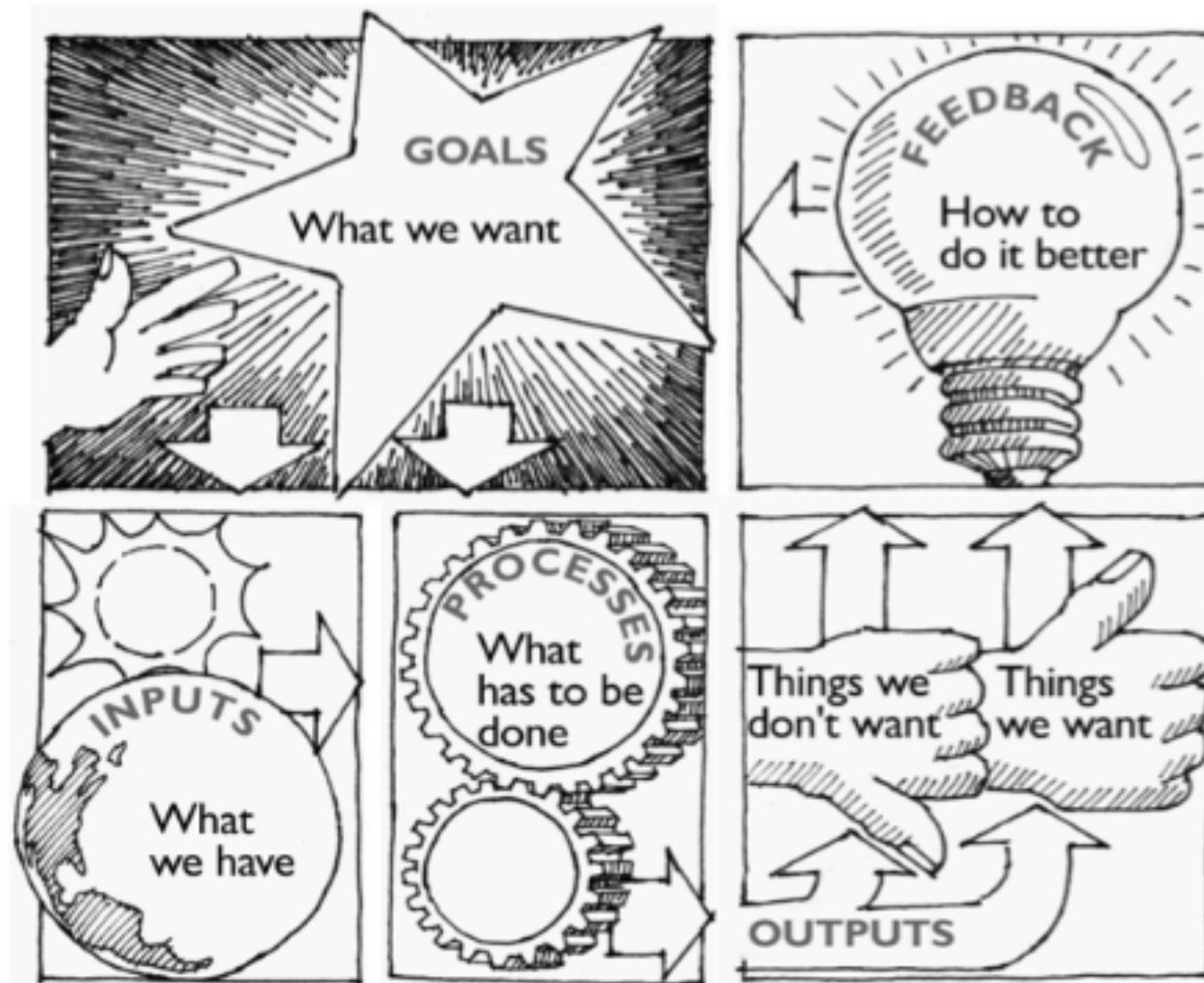


Our *Energy Is Electrifying!* Unit also complements the document published by the U.S. Department of Energy entitled *Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education*. (Some copies available on hand-outs table, or online at the following website:

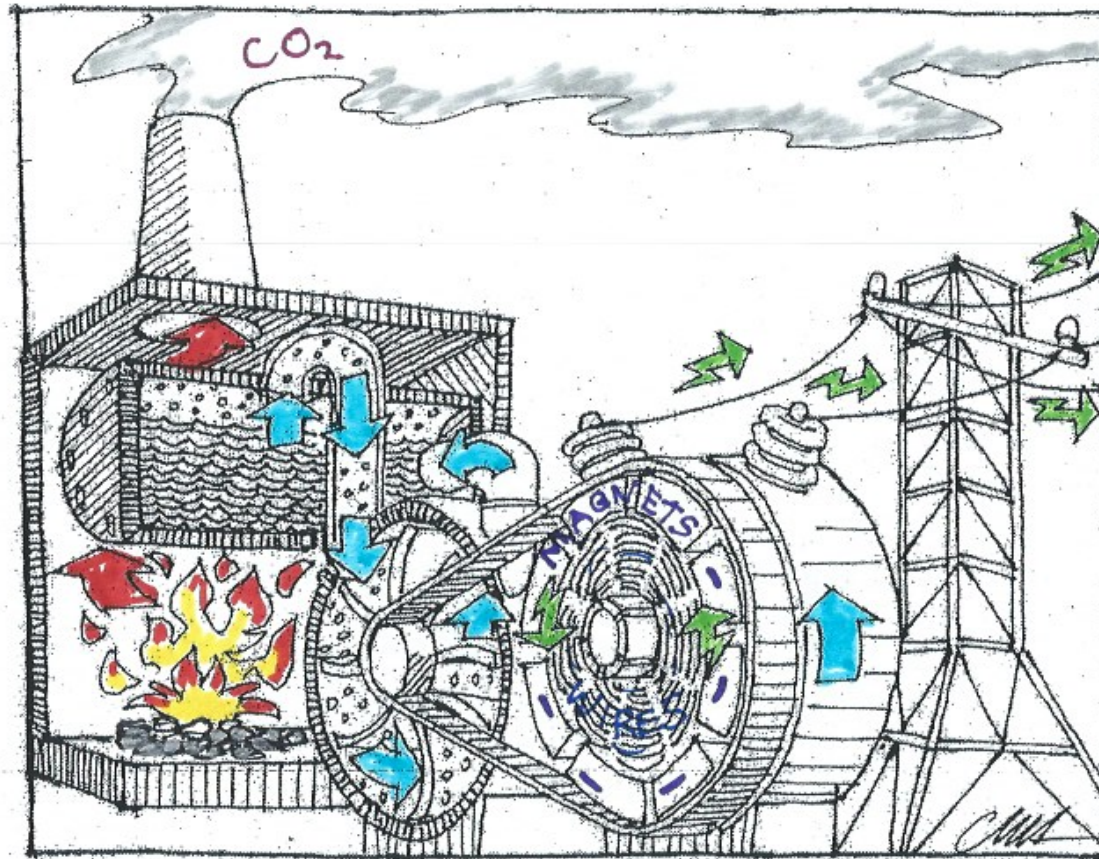
<http://library.globalchange.gov/energy-literacy-essential-principles-fundamental-concepts-for-energy-education>



Energy Systems Thinking



STEAM-POWERED ELECTRIC GENERATOR



Materials Demonstrated at NSTA Workshop

- Materials in Professional Development Teacher Kit
- Devices for measuring Electric Output
 - Multimeter
 - Kill-A-Watt Meter
- Demo – Hand-made Electromagnet generator
- Hands-On Stations:
 - Wind Energy
 - Solar Energy

Student Data Sheet for Renewable Energy Stations

Using Renewable Energy Worksheet

Names of People in Your Group _____

Solar Power:

- 1) How many volts does the solar panel generate? _____
- 2) What can you do to make it generate half that number?

- 3) Will the solar panel make the LED bulb light? **yes** or **no**
- 4) Can you use the solar energy to light 2 LED bulbs? (Use 2 solar panels connected together.) **yes** or **no**

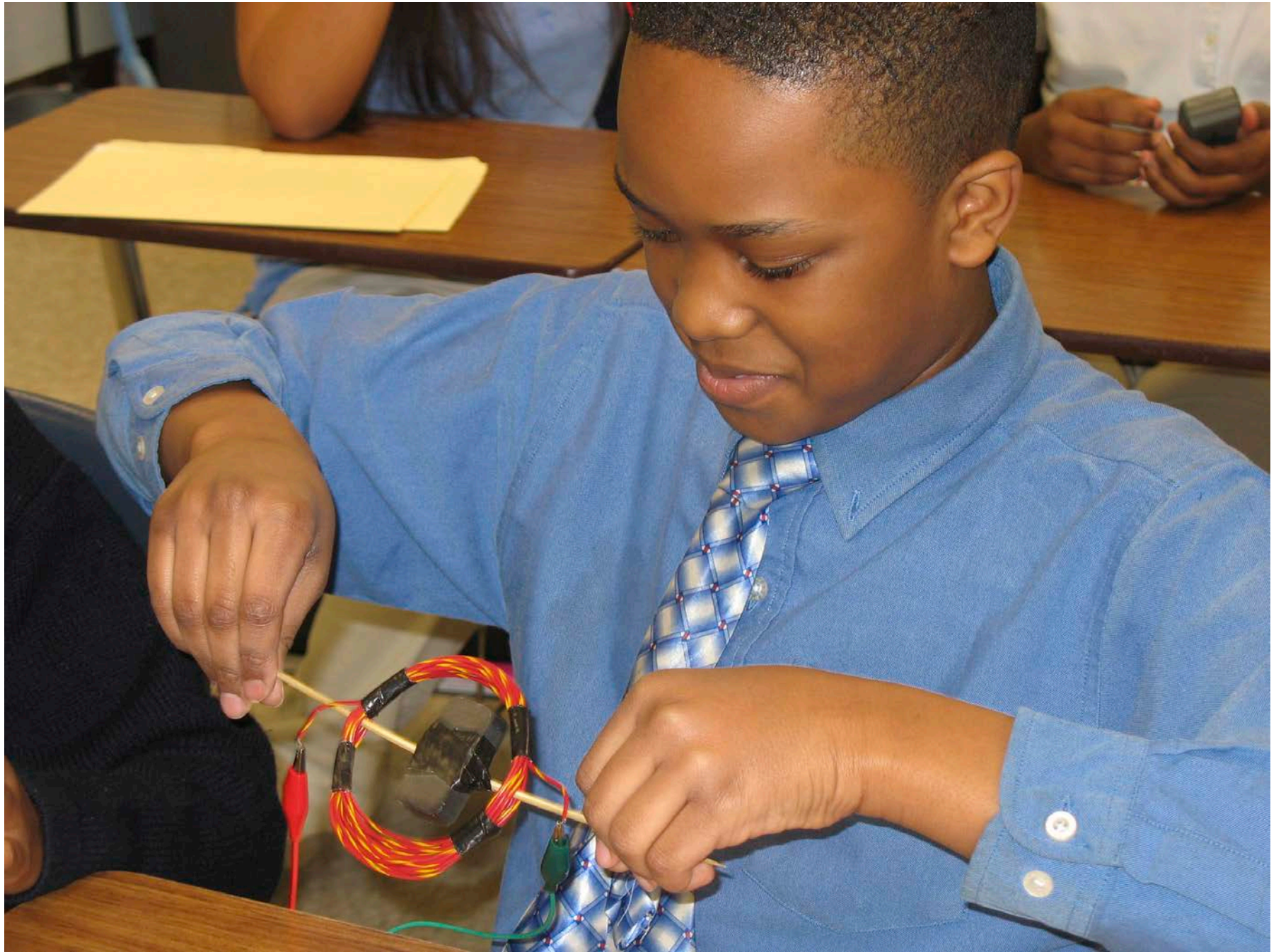
Wind Power:

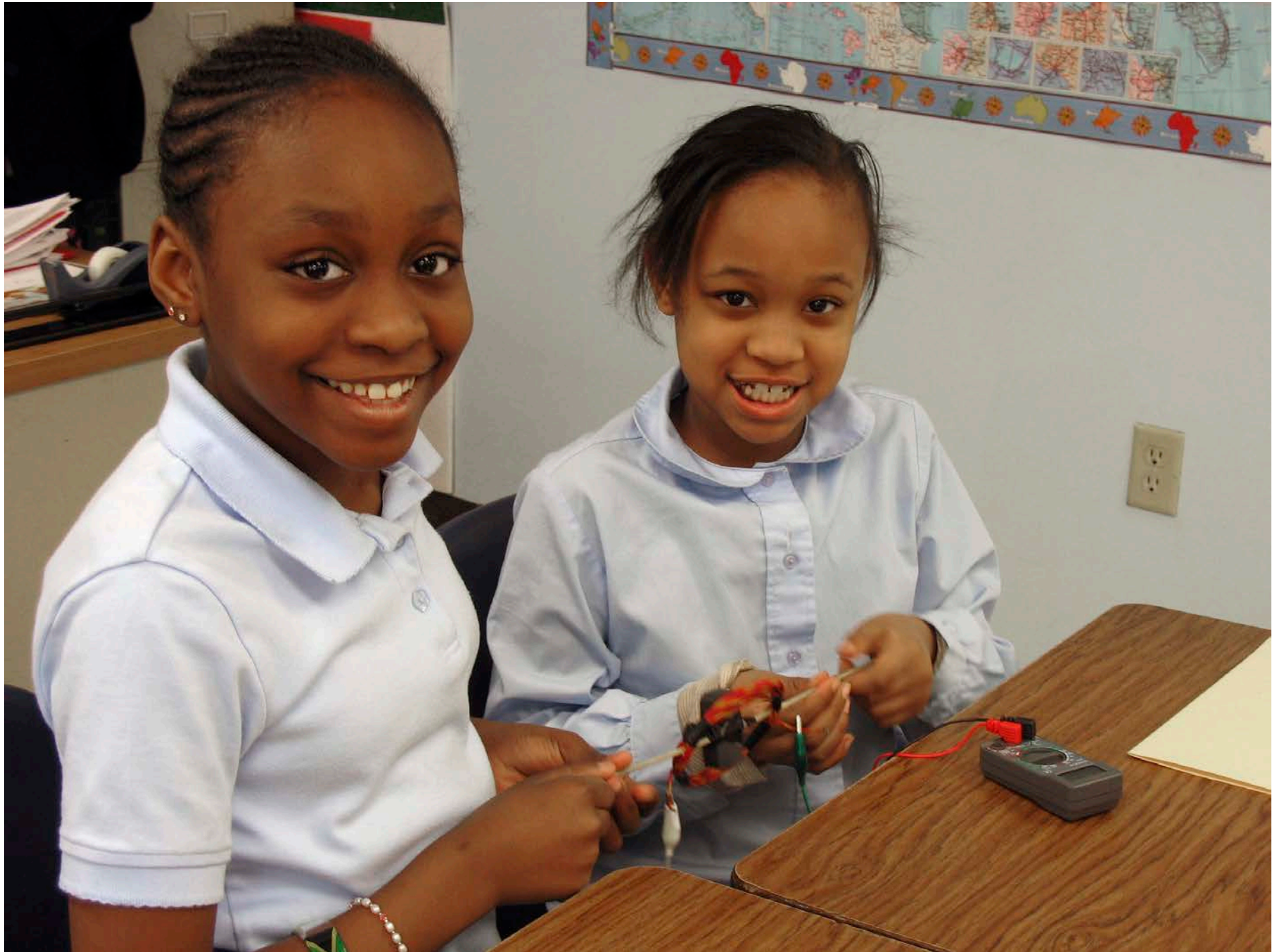
- 1) How many volts does the wind turbine generate? _____
- 2) What can you do to make it generate half that number?

- 3) Will the wind turbine make the LED bulb light? **yes** or **no**
- 4) Can you use wind energy to light 2 LED bulbs? **yes** or **no**









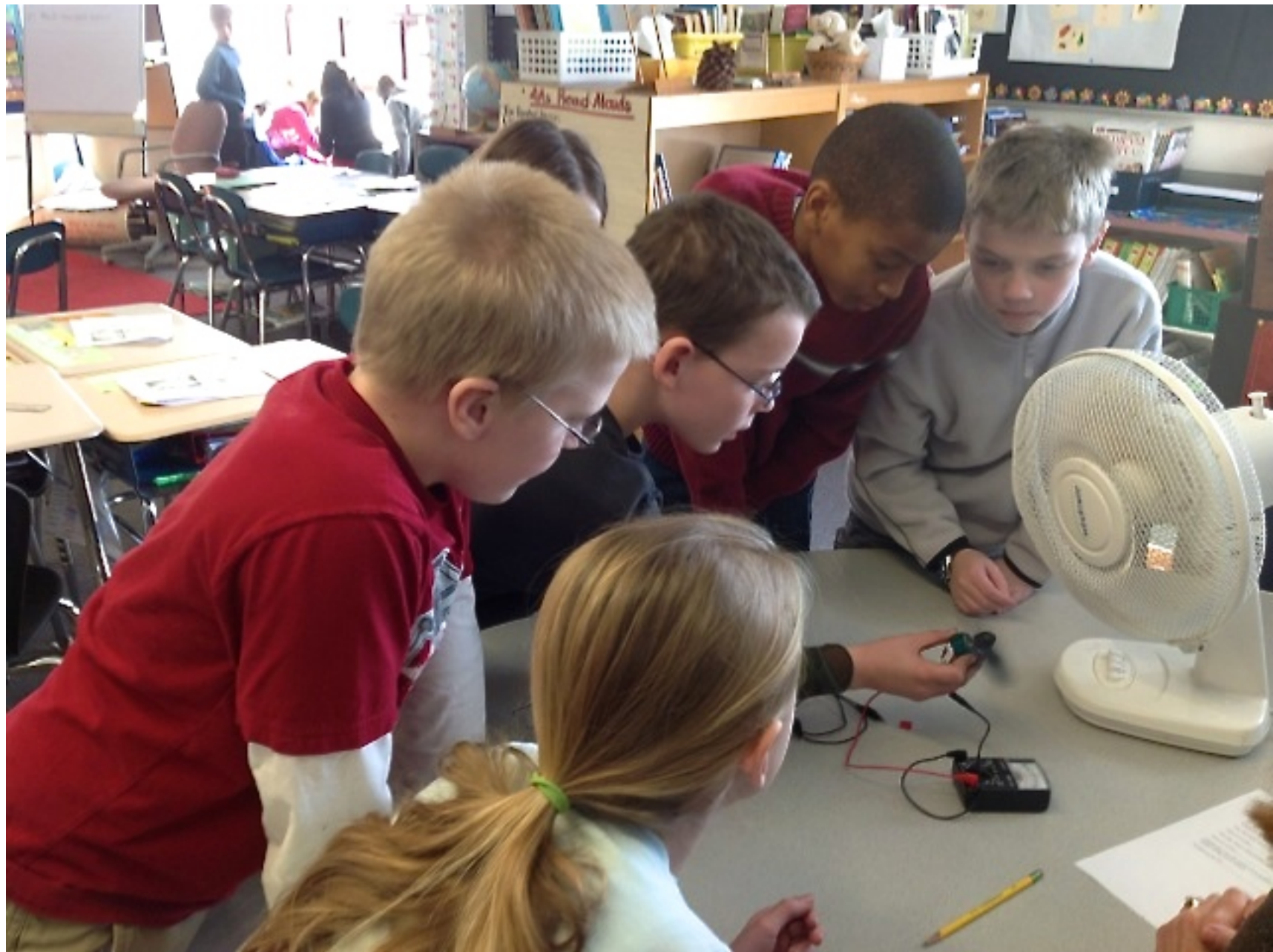


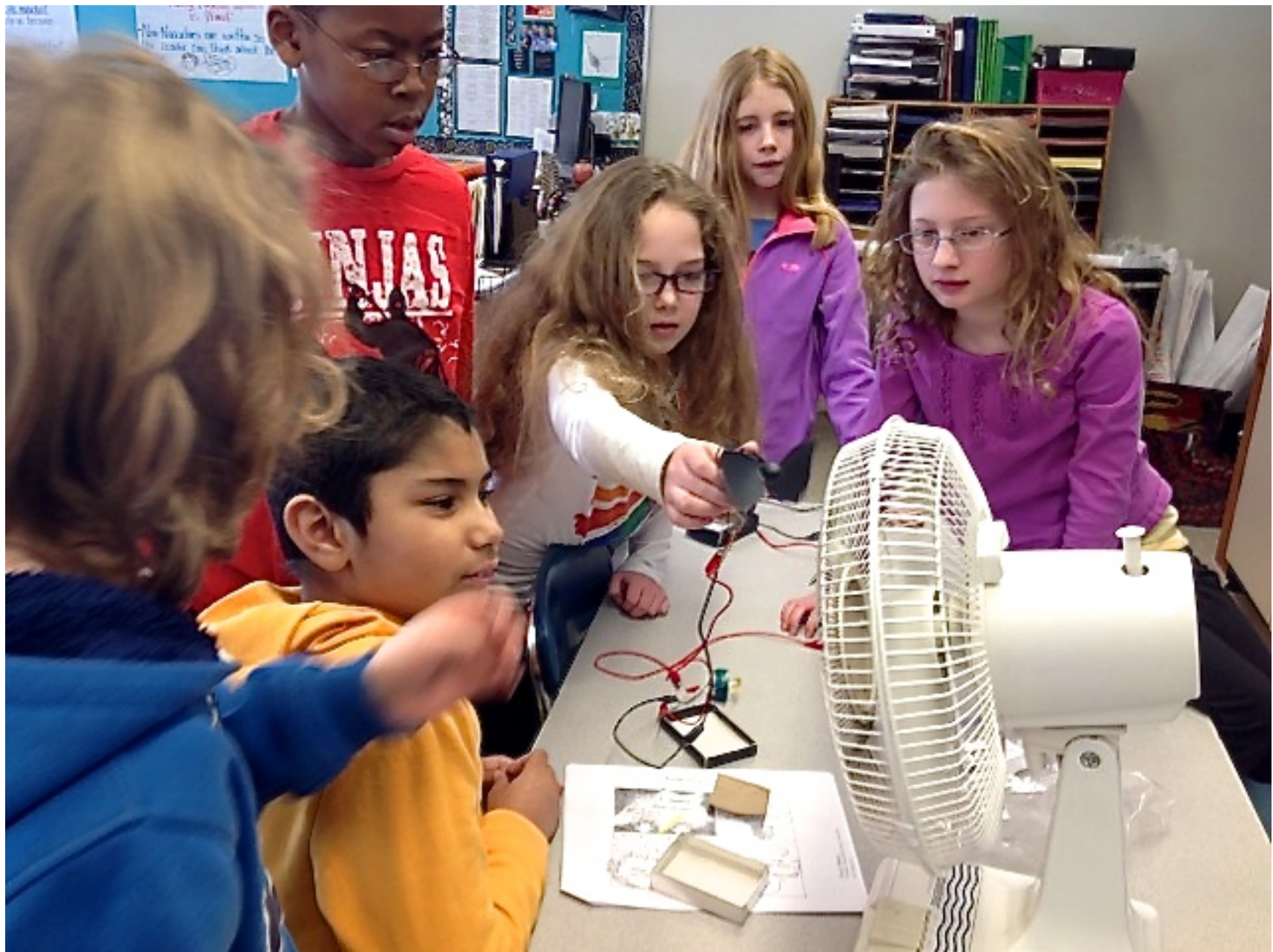


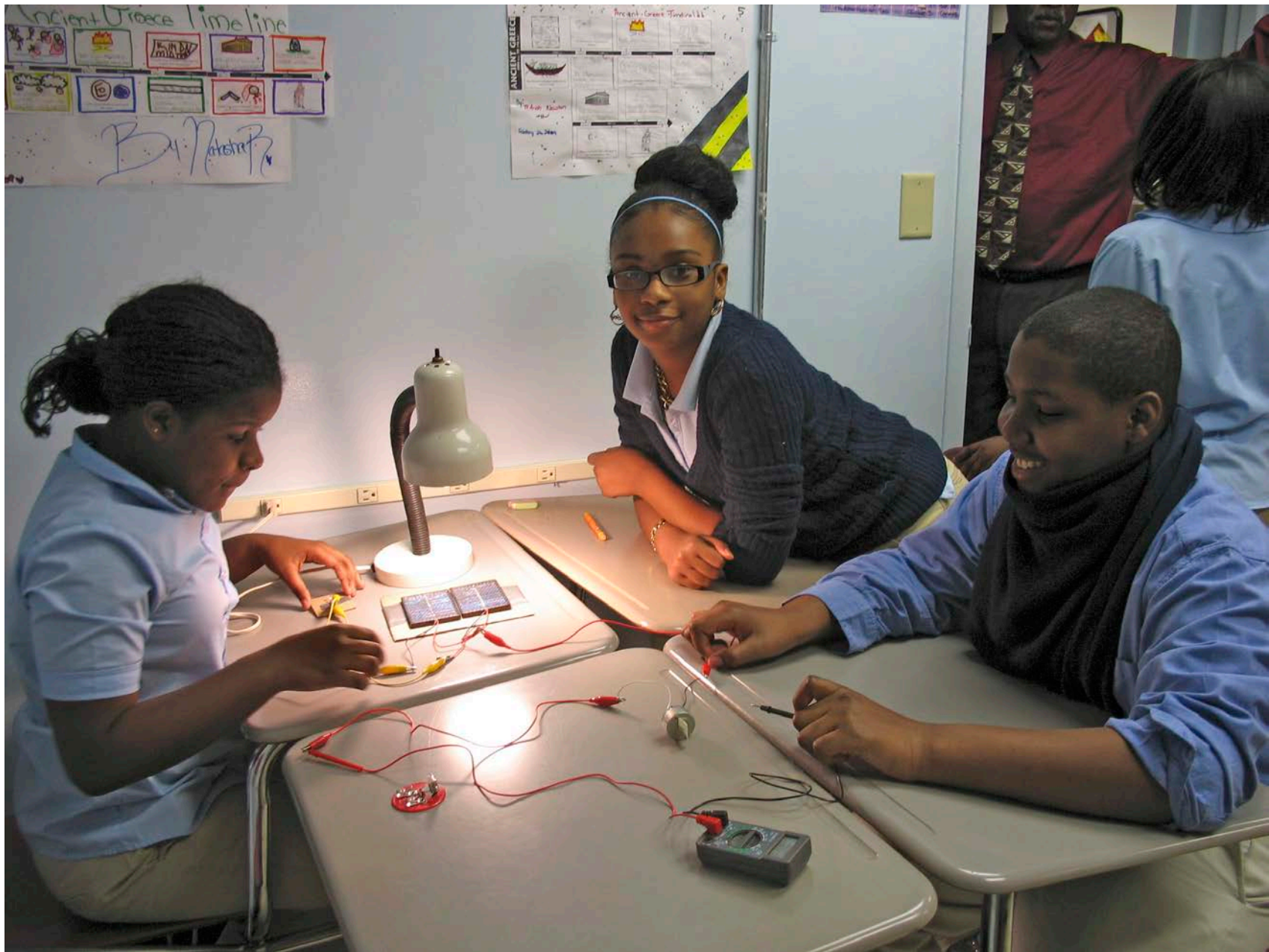


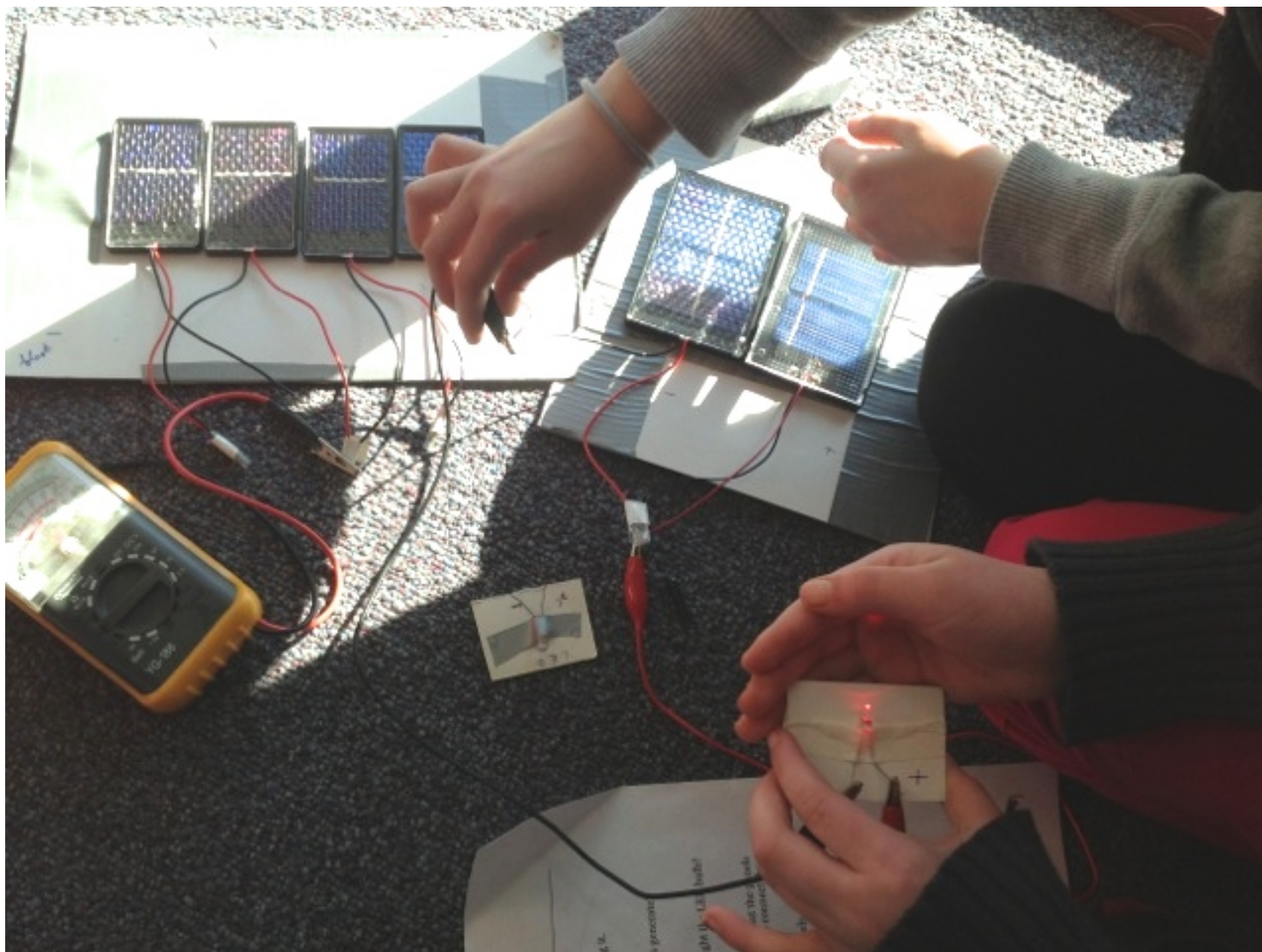










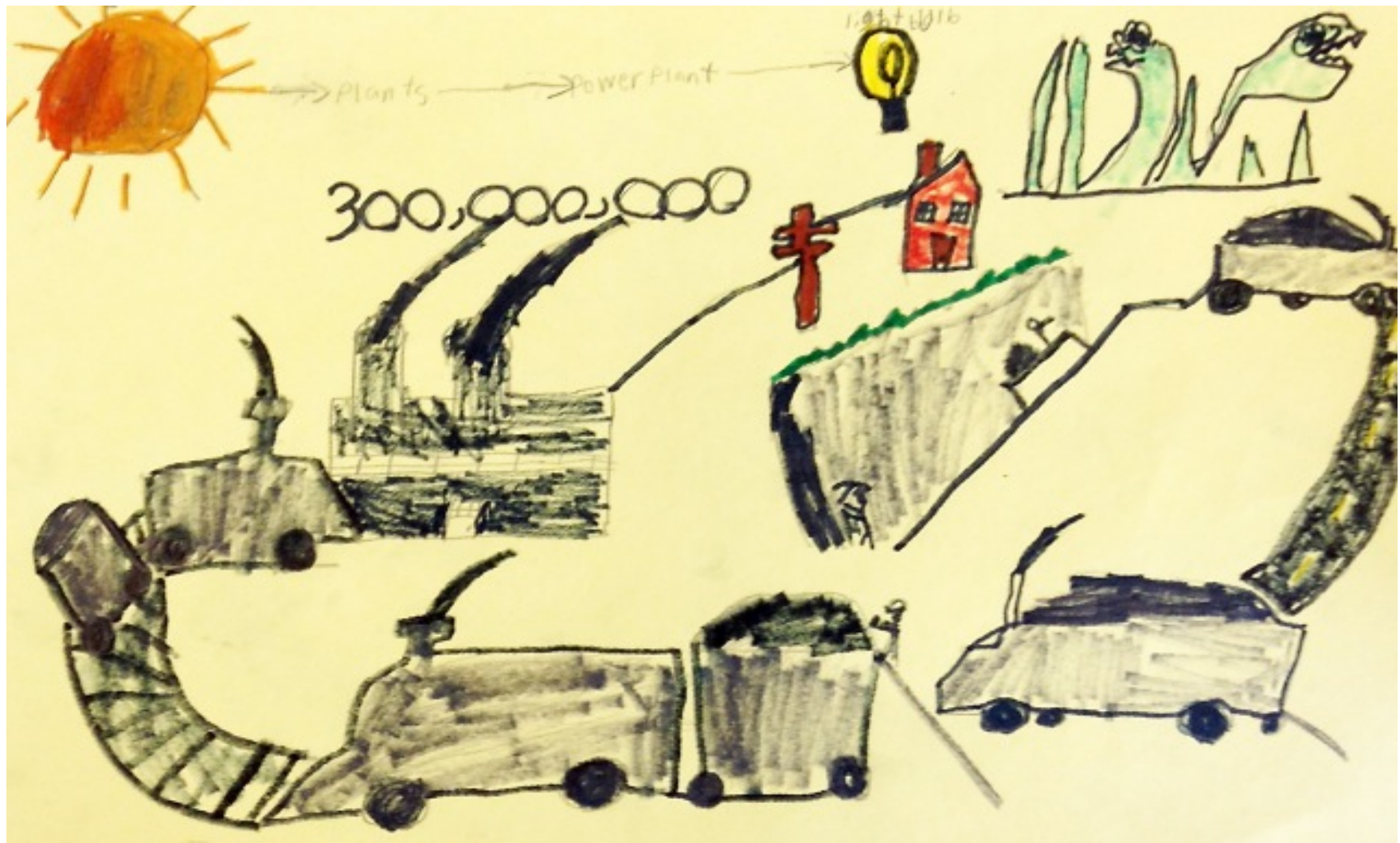






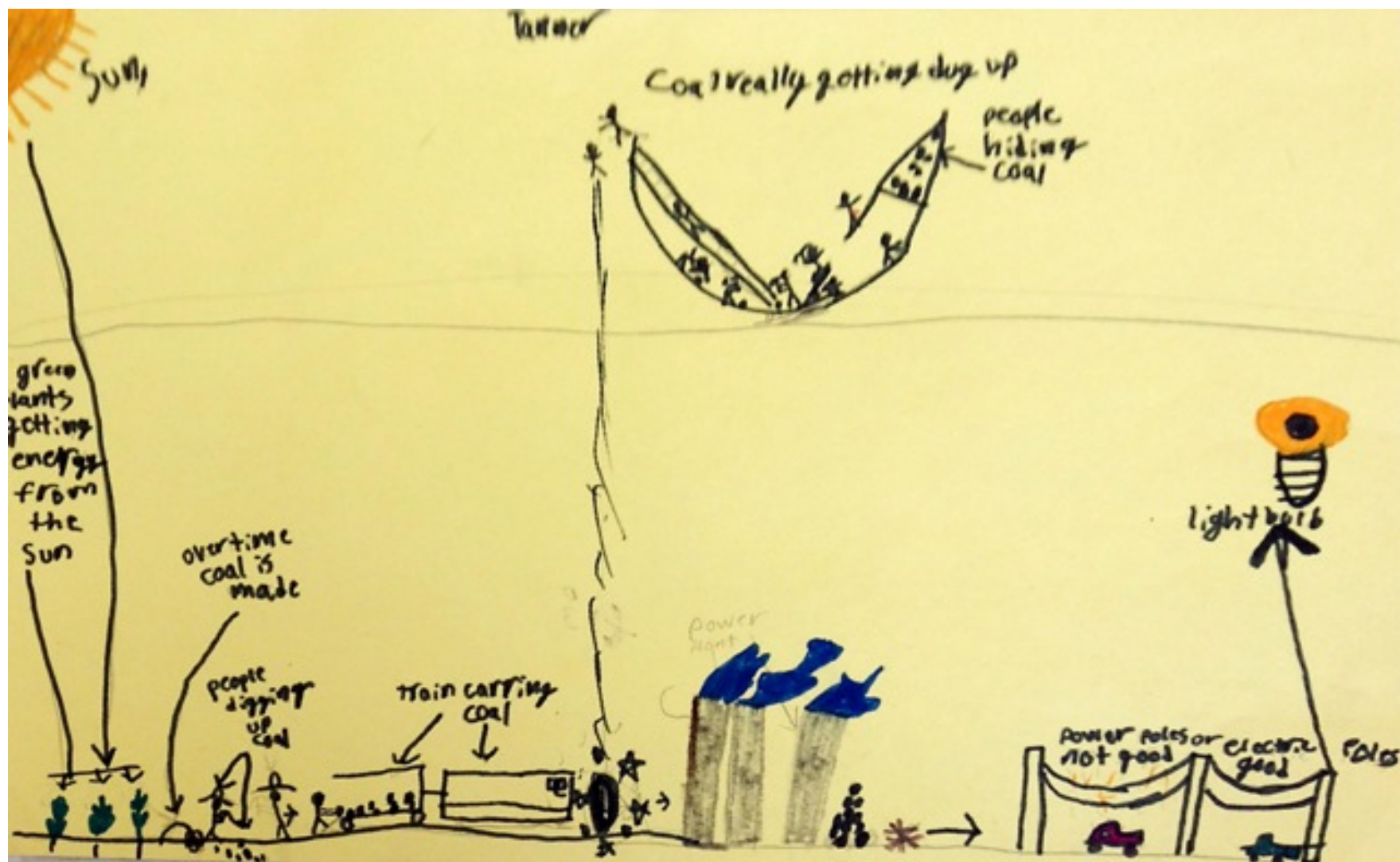


Energy Chain Student Drawings









Sara C.

