Unit Authors:

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1. PLANNING A UNIT AROUND “BIG SCIENCE IDEAS”

Group Member Science Area Focus: ENERGY
Middle School Conceptual physics
High School engineering

What do you want to teach?

Disciplinary Core Idea(s) focus of Lesson: (Identify DCI at the bullet point(s) grade band progression)
MS PS 3.3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
ENG-10 Demonstrate the application of science and math principles to the thermal engineering process

What are the Performance Expectations that you are working toward?

Using dye based solar cells, demonstrate the 3 forms of energy transfer

Why is/are this a core idea(s) in science?
Identify the DCI in Framework for K-12 Science Education using the following links:
Physical Science: https://www.nap.edu/read/13165/chapter/9
Life Science: https://www.nap.edu/read/13165/chapter/10
Earth and Space Science: https://www.nap.edu/read/13165/chapter/11
Engineering, Technology, & Applications of Science: https://www.nap.edu/read/13165/chapter/12

What does the Framework say about the core idea(s)?
Summary:
After reading through the specific DCI focus/foci of your unit, write a summary in your own words that describes why this is a/these are core idea(s) in science, along with what facets of this core idea(s) are most important for students to understand:

Summary: (example of unpacking)

Energy cannot be created or destroyed, only transferred. Solar power is generated by converting sunlight to either thermal or electric energy. To convert the sun's energy to electricity, photovoltaic cells (PV cells for short) are needed. When light hits a PV cell, some reflects back, some passes right through and some is absorbed. The absorbed light causes electrons to flow in the PV cell, creating a current and a voltage (electricity), which creates power.
ANCHORING PHENOMENON

**Identify a scientifically rich, complex phenomenon** that students will require students to use multiple principles that are central to the DCI to explain (an occurrence or event that happens(ed) in the world) [This will serve as the reason for engaging in the unit.] Resources for identifying anchoring phenomena (1, 2)

Anchoring Phenomenon chosen to anchor the unit: Surface of the Sun video
https://youtu.be/2U3ucaVzRqQ

Explain how we can harness the energy from the sun to fit our energy needs

**Identification of Crosscutting Concept(s)** that can also be used to understand/explain the phenomenon: (explain this connection):

Crosscutting Concepts:

- Energy and Matter: Flows, Cycles, and Conservation:
  - MS-ESS2-4. Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity.
  - ENG-10.01 Identify the three ways heat is transferred
  - ENG-10.04 Describe work in thermal systems

**Provide a Target Explanation of Phenomenon** [Provide a written explanation of the phenomenon, being sure to consider how the role of the identified crosscutting concept(s) you identified above as part of the explanation] (Note: the explanation should identify how science principles are coordinated to explain the occurrence or event that happened in the world) (ex. target explanation for explaining ramps with models):

Target explanation of phenomena:

Demonstrations: explain

Energy conversions happen when energy changes from one form to another, or moves. Solar panels transfer the light from the sun to heat or electrical energy. can come in many forms

This demonstrates how energy can be transferred.

**From your Target Explanation, identify principles within the explanation** that are central to students explaining the phenomenon [this can serve as an early ‘Gotta Have List’ that you go into the lesson considering, while also serving as a guide for identifying science activities students can engage in as part of the unit after initial modeling to work on developing more sophisticated explanations of the phenomenon]:
Principle A:
Conduction
Convection
Radiation
Proton
Electron
Transfer
Energy
Solar

Principle B:
Voltage
Amps
Resistance
Efficiency
Sicilia
Volt meter
Dye sensitised
photovoltaic

For each science principle identified above, choose one activity, reading, video, simulation, or investigation that will help students understand this principle and begin to see its usefulness in explaining the anchoring phenomenon. Do this for each principle below: [possible resources 1, 2]

Principle A:
- phenomenon
- Activities:
  - Conduction, Convection, and Radiation: An Introduction:
    - http://www.uen.org/Lessonplan/preview?LPid=21567
      - Convection: Spinner
      - Conduction:
      - Radiation: Test yourself: (energy transfers)(answers)
- Earth’s Energy budget:
  - https://drive.google.com/open?id=0B6Ykbno91HFfWM2hlVkVKTWlHWkk

Principle B:
Creating dye sensitized Solar cells lab
- https://drive.google.com/open?id=1O4uwO6kclwdTIqVznU50TIljF1ypoviJE8EFihUBHM

Identify Ideas and Resources that might surface as students begin to reason about this phenomenon (use the AAAS Science Literacy Maps, NGSS Disciplinary Core Idea Progressions, and past experiences working with students around the principles (i.e., A, B, C…) above [these include ideas they may have learned previously or common ways students might think about one or more of these ideas]:

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Identify Ideas and Reasoning:

Energy forms and changes
https://phet.colorado.edu/en/simulation/legacy/energy-forms-and-changes

Conductivity
https://phet.colorado.edu/en/simulation/legacy/conductivity

Future Ideas and Resources that learning in this unit will support. Use the AAAS Science Literacy Maps and NGSS Disciplinary Core Idea Progressions to identify what students will be able to learn when they have developed facility with the principles focused on in this unit:

Future Ideas and Resources:

Decisions about using technology:
http://strandmaps.dls.ucar.edu/?id=SMS-MAP-1273

Solar Cooker
http://www.newhaven.science.org/NewCTStateScience/s1energylabstudent.htm

2. ELICITING AND ACTIVATING STUDENTS' IDEAS ABOUT A PUZZLING PHENOMENON (FOR THE PURPOSE OF ADAPTING INSTRUCTION)

THE TALK SCIENCE GOALS AND TALK MOVES IS A RESOURCE FOR RESPONSIVENESS TO STUDENT THINKING THROUGHOUT THE UNIT . Additional resources are the Talk Science Primer and the Ambitious Science Teaching Discourse-Primer referenced next:

Eliciting students' initial scientific hypotheses in order to plan for further instruction. The goal of this discourse is to draw out students' understandings of a phenomenon (e.g. a bicycle rusting in the backyard) that is related to an important scientific idea (in this case chemical change or conservation of mass). After the lesson we analyze students' ways of talking about it in order to adapt upcoming learning experiences (AST Discourse-Primer, 2015, p. 7.)

Day 1: Outline how you plan to engage students in creating/sharing their initial models that explain the anchoring phenomenon. How will you introduce the phenomenon? What is your plan for eliciting student initial models (e.g. group sizes, directions to students including some introduction to what a model is and what you want to be sure students do as they share their initial ideas—be sure to include where and how you will use ‘Gotta Have Lists’ (taken from ambitiousscienceteaching.org) to help focus students reasoning during this process. Include any videos, templates, webresources, etc. you might want to use. Describe how students will share their initial models with peers in small group and whole group discussions/sharing: (Example Day 1)

Outline Day 1:
Question: Why do we need solar energy?
Students work in small groups to discuss this
PPT notes which include phenomena video (Surface of the Sun as You've Never Seen it)
3. HELPING STUDENTS MAKE SENSE OF SCIENCE ACTIVITIES (WITH THE AIM OF USING SCIENCE PRINCIPLES BEHIND ACTIVITIES TO EXPLAIN ANCHORING PHENOMENON)

**AST Discourse Strategies**

- Making sense of data/information. The goal here is to help students recognize patterns in data, critique the quality of data, and to propose why these patterns exist. What, for example, is going on at the unobservable level that explains our observations?
- Connecting activities with big scientific ideas. The goal of this practice is to combine data-collection activities with readings and conversation in order to advance students' understanding of a broader natural phenomenon. This conversation is different from the previous one, in that students are not trying to explain the outcome of an activity, but to relate the activity to a bigger science idea or puzzle that the unit is framed around. (AST Discourse-Primer, 2015, p. 7.)

**Day 2-5:** (Include time needed for each activity included in Days 2-5) [use more or less days as needed for engaging students in science activities depending on what might be needed to explain the anchoring phenomenon]

Identify how you will ‘put on the table’ science principles (i.e., you identified above that are central to explaining the anchoring phenomenon (i.e., Principle A, B, C...) using science activities you identified for each principle above (e.g., activity, reading, video, simulation, investigation) that prioritizes students engaging in science and engineering practices to develop an understanding of the principle that will be helpful in later stages of the unit in explaining the anchoring phenomenon. Describe how you will use ‘Thank Summary Tables [1, 2]’ (taken from ambitiousscienceteaching.org) across these days/activities to help students keep a record of activities, ideas, and evidences that will be used to later in the unit to revise their initial models of the anchoring phenomenon. (Example Days 2-5)

**Outline Day 2-5:**
Day 2  Demo: [https://www.youtube.com/watch?v=MXk57NIM3w8](https://www.youtube.com/watch?v=MXk57NIM3w8)
Can be purchased at Amazon Brass Thermal Expansion experiment

Notes: Heat is made of molecules [https://drive.google.com/open?id=0B2EeL36I2tOgSXdqdGFWWDhGNkk](https://drive.google.com/open?id=0B2EeL36I2tOgSXdqdGFWWDhGNkk)

Day 3 and Day 4: students will be exposed to a variety of activities that illustrate the difference between the 3 types of heat transfer: conduction, convection and radiation.

Large group discussion will take place to create a Gotta Have List for heat transfer and pick 1 type to illustrate 3D drawings: top, middle, bottom views

Day 5: Sharing of drawings: Gallery walk

4. PRESSING STUDENTS TO CONSTRUCT EVIDENCE-BASED EXPLANATIONS
**AST Discourse Strategies**

- Pressing students for evidence-based explanations. This discourse is designed to happen near the end of a unit, but elements of this conversation can also happen any time the teacher is trying to get students to talk about evidence. The goal of this discourse is to assist students in using multiple forms of evidence, gathered during a unit, to construct comprehensive explanations for a phenomenon that has been the focus of the unit.

**Day 6-7:** (Include time needed for each activity included in Days 2-5)

**Part 1.** In this part of the unit, students will engage in revisiting and negotiating (with the teacher) the Gotta Have List to be sure that it represents what they think should be included in the final models. Additionally, students should engage in refining their initial models by both referring to the finalized ‘Gotta Have List’ and ‘Summary Table’ that was developed across the unit. You might also consider having groups of students comment on other groups’ initial models with ‘Sticky Notes’ prior to students making final revisions to their group models (see ‘Sticky Notes [1, 2]’ taken from ambitiousscienceteaching.org). Once students are ready to revise their models based on what they learned across the unit, be sure to identify how you will ensure that they use the Gotta Have Lists and Summary Tables as resources for supporting their final revisions. Be sure to include your complete plan for supporting student groups in revisiting their initial models (e.g. directions to students. Include any templates or resources you will use). (Example Days 6-7)

Outline Day 6-8:

Day 6-7 :Lab: Titanium Dioxide Raspberry Solar Cell [https://drive.google.com/open?id=1O4uwO6klwdT1qVznU5O7IliF1ypovijE8EFibUBHM](https://drive.google.com/open?id=1O4uwO6klwdT1qVznU5O7IliF1ypovijE8EFibUBHM)

Day 8: Modeling Solar Cell understanding [https://drive.google.com/open?id=1x7PFP0litP4bOA4s-GKq7UFY_LiX4Ewo7ci7BqgY8o](https://drive.google.com/open?id=1x7PFP0litP4bOA4s-GKq7UFY_LiX4Ewo7ci7BqgY8o)

**Part 2.** Sharing revised models to work at reaching class consensus model. Describe plan for students sharing their revised model and for engaging in consensus model building (see ‘Tips for Facilitating a Consensus Discussion’ resource from NGSX project) as a whole class.

Plan for students sharing revised model and for engaging in consensus model building:

Gallery Walk for suggestions [https://drive.google.com/open?id=1RkHGNIDWqm1QR-HDpUqNtm382iXwVKFDS8TMau7R5Ze](https://drive.google.com/open?id=1RkHGNIDWqm1QR-HDpUqNtm382iXwVKFDS8TMau7R5Ze)

10 minutes to make changes before submission

**Part 3.** Individual Student Evidence-Based Explanation. As a final summative assessment of the unit, consider asking students to develop a written evidence-based explanation of the anchoring phenomenon. In this, consider asking them to ensure they include reference to all important ideas included in the final class Gotta Have List and
Summary Table. And, consider asking them to ensure they use all evidence chronicled in the rows of the summary tables (e.g., patterns and explanations for patterns) in their written explanations.

Plan for individual student evidence-based explanation:
Based on sample interactive stations class comes up with a GO TO list of vocab to include

**Resource-Rubric EXAMPLE** as Possible Resource for Summative Assessment of Group Consensus Models or Individual Student Evidence-Based Explanations. This rubric was developed by using the principles identified above that were important for explaining the anchoring phenomenon and using these as indicators for the rows. The levels of each indicator is then assessed by considering the extent to which students or groups models or explanations are useful in explaining the anchoring phenomenon using the principle of each row.

**EXTENSION** (Optional)

**APPLICATION OF NEW IDEAS TO NEW PHENOMENON**
Identify a new phenomenon for students to explain that will allow them to demonstrate to themselves and you that they have a solid understanding of process of modeling/explanation/argumentation and the disciplinary core ideas and crosscutting concept at the heart of the lesson.

Other related activities:

- 3 generations of solar cells [https://drive.google.com/open?id=1bFRJKPfuFhm17Hcvx3UrgCzFg-ouw4pV-MQOz7r27O8](https://drive.google.com/open?id=1bFRJKPfuFhm17Hcvx3UrgCzFg-ouw4pV-MQOz7r27O8)

- Concentrated solar power: [https://www.teachengineering.org/content/cub_/lessons/cub_pveff/Attachments/cub_pveff_lesson04_fundamentalsarticle_v2_dwc.doc](https://www.teachengineering.org/content/cub_/lessons/cub_pveff/Attachments/cub_pveff_lesson04_fundamentalsarticle_v2_dwc.doc)


- Zero Energy housing: [https://www.teachengineering.org/activities/view/cub_housing_lesson05_activity1](https://www.teachengineering.org/activities/view/cub_housing_lesson05_activity1)

- Wind turbine generating and measuring electricity: [https://www.teachengineering.org/activities/view/cub_housing_lesson04_activity1](https://www.teachengineering.org/activities/view/cub_housing_lesson04_activity1)

- Copper Tape Circuit Cards [https://www.youtube.com/watch?v=7hb-9eUpfbQ&t=212s](https://www.youtube.com/watch?v=7hb-9eUpfbQ&t=212s)

- Homemade Operations Game [https://www.youtube.com/watch?v=vJt9EVP4vD1](https://www.youtube.com/watch?v=vJt9EVP4vD1)
References


