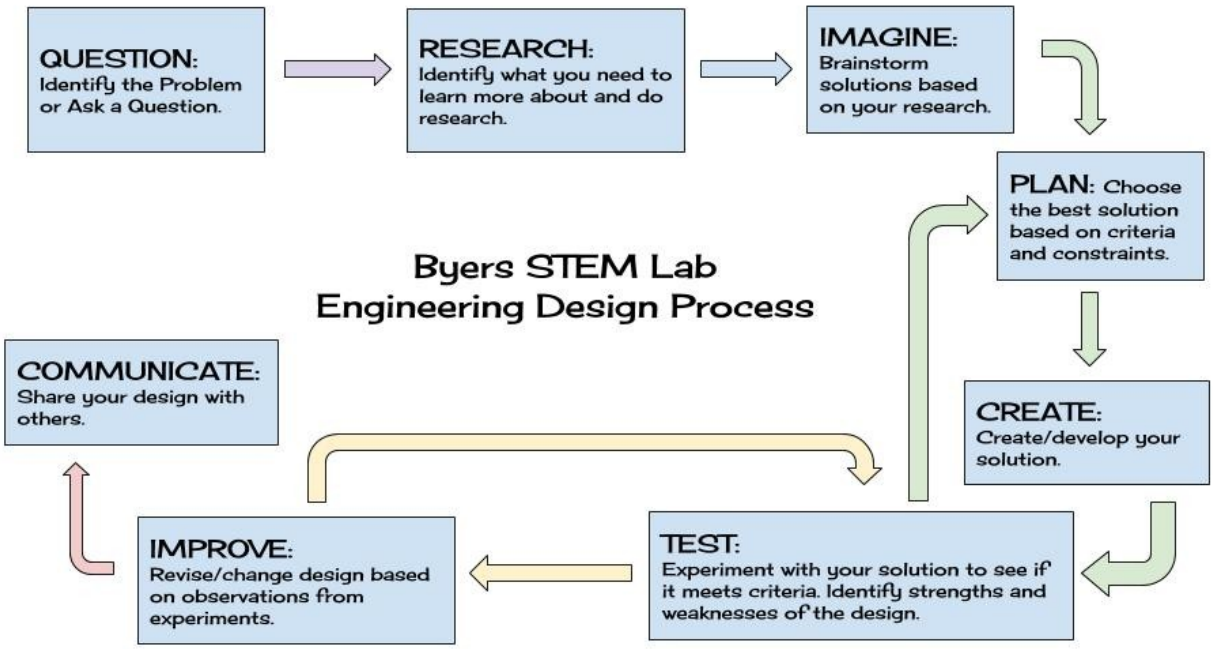
Kerrie Lalli
Major Project
Phase I – Research and Planning

1. Identify the "Big" concept to be covered by the engineering design challenge.

Science: Heat can be transferred over a distance and used for practical applications.

Engineering: Designing a solution is a process that requires repeated revisions to produce an optimal product. (See version of Engineering Design Process that I use with my students below. I intentionally included elements of PBL such as communicate findings.)



2. Research appropriate learning standards associated with the topic.

From 5th Grade NC Essential Standards for Science: (Highlighted portions of the unpacked standard are critical to this project)

5.P.3.1 Explain the effects of the transfer of heat (either by direct contact or at a distance) that occurs between objects at different temperatures. (conduction, convection or radiation).

> *Students know that when warmer things are put with cooler things, the warmer things lose heat and the cool things gain it until they are all at the same temperature. Students know that a warmer object can warm a cooler object by contact or at a distance. Conduction is the transfer of thermal energy between things that are touching. Conduction can happen within one object. (For example, thermal energy can be conducted through the handle of a metal pot.) Convection is the movement of thermal energy by the movement of liquids or gases. Convection in the oceans and atmosphere helps to move thermal energy around Earth, and is an important factor influencing*

weather and climate. Radiation is the transfer of energy by electromagnetic waves. Electromagnetic waves can carry energy through places with or without any matter. The Sun is the main source of electromagnetic energy on Earth. Part of this energy, light, is used by producers to make food. Radiation can also happen in other circumstances (i.e. sitting in front of a fireplace).

5.P.3.2 Explain how heating and cooling affect some materials and how this relates to their purpose and practical applications.

Students know that heating and cooling can cause changes in the properties of materials, but not all materials respond the same way to being heated and cooled. Students know that heating and cooling cause changes in the properties of materials, such as water turning into steam by boiling and water turning into ice by freezing. Students know and notice that many kinds of changes occur faster at higher temperatures. Students know that some materials conduct heat much better than others, and poor conductors can reduce heat loss.

Students need not come out of this grade span understanding heat or its difference from temperature. More important, students should become familiar with the warming of objects that start out cooler than their environment, and vice versa. Computer lab ware probes and graphic displays that detect small changes in temperature and plot them can be used by students to examine many instances of heat exchange. Because many students think of cold as a substance that spreads like heat, there may be some advantage in translating descriptions of transfer of cold into terms of transfer of heat.

3. Identify and discuss the different types of problem solving and declarative/procedure knowledge needed.

Problem-Solving: This is a Design Problem. Students will have to come up with a design to solve the problem that is part of the scenario given. The solution will be specifically designed to meet the criteria and constraints outlined in the story.

Declarative Knowledge: This problem involves all three types of declarative knowledge.

- Facts
    - What is dehydrated food and how do you rehydrate it?
    - How do you cut a water bottle?
    - What are the useful properties of aluminum foil? Of black paper?
- Concepts
    - Based on its properties, a material can reflect/focus light; can absorb heat energy
    - Energy can be transferred via radiation over large distances
- Principles
    - Heat energy from the Sun can be used to heat other materials, and the efficiency of this process will be better if the properties of those materials are conducive to retaining heat energy

Procedural Knowledge: This is an Ill-Defined Problem. There are many ways to solve this problem and many different designs can be successful. Students must:

- Identify the essence of the problem (How do you heat water using the Sun?)
- Gather background information on a variety of aspects of the problem (dehydrated foods, rehydrating foods, solar cookers, radiation, properties of materials)
- Determine how they will solve the problem considering each of the criteria and constraints
    - Portability
    - Ability to heat water
    - Cooking the dehydrated food
    - How to best use limited materials

4. Explore objectives and ancillary concepts/content covered by the project.

From 4th Grade NC Essential Standards for Science:

- 4.P.2.1 Compare the physical properties of samples of matter (strength, hardness, flexibility, ability to conduct heat, ability to conduct electricity, ability to be attracted by magnets, reactions to water and fire).
- 4.P.3.2 Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.

5. Identify possible activities.

- In Hot Water PBL from Wake Forest CERTL
    - Includes criteria and constraints built into the story
- For Research:
    - Solar Cookers Exploration
    - Experiment with materials to determine their properties
    - Explore Learning Gizmos Radiation Interactive
- Collaboration
    - Using online resources such as Padlet, Flipgrid, and Discussion Boards
- Building a Prototype
    - Students will have the option to pick up bags of materials to complete a prototype (This works because of the constraints on the materials they can use.)

6. Select the best activity for your classroom.

In Hot Water PBL from Wake Forest CERTL

1. Launch the problem with video
2. Compile lists of “what we know” and “what we need to know” via Padlet (whole class)
3. Determine criteria and constraints for the project (whole class)
4. Brainstorm ways to solve the problem in terms of how materials can be used (small groups, then share out findings)
5. Research solar water cookers using web resources (Jigsaw activity)
6. Research concepts of radiation, including reflection and absorption, using Explore Learning Gizmos Radiation Interactive Lab (partner work)

7. Plan design for solar water heater, keeping in mind criteria and constraints; present ideas via Flipgrid (individual)
8. Provide feedback to peers on initial designs; use feedback to revise initial plans (individual)
9. Build solar water heaters and test at home; redesign as needed (individual)
10. Present final design, including challenges encountered and how they were addressed (individual)
11. Peer feedback on final designs, allowing for students to redesign if they'd like