Engineering Design Challenge: Research and Planning

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Feel the Heat from NASA/Design Squad "On the Moon" Design Guide

The "Big" concept to be covered by the engineering design challenge

Energy conversion is the overarching concept to be the focus of this engineering design challenge.

Learning standards associated with the topic

I currently am an assistant for a 4th grade gifted math/science class. During second semester, we do an energy unit, and I would love to introduce this design challenge to my lead teacher. The following standards/practices/concepts would be addressed with this challenge:

4th Grade NGSS

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

ETS1.A: Defining Engineering Problems
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.

Crosscutting Concepts:

Energy and Matter: Energy can be transferred in various ways and between objects.

Influence of Science, Engineering and Technology on Society and the Natural World: Engineers improve existing technologies or develop new ones.

Science is a Human Endeavor : Most scientists and engineers work in teams. Science affects everyday life.

Common Core-Math

Mathematical Practices

1 Make sense of problems and persevere in solving them.
2 Reason abstractly and quantitatively.
3 Construct viable arguments and critique the reasoning of others.
4 Model with mathematics.
5 Use appropriate tools strategically.
6 Attend to precision.
7 Look for and make use of structure.
8 Look for and express regularity in repeated reasoning.

Measurement and Data
Represent and interpret data.

The different types of problem solving and declarative/procedure knowledge needed

Some declarative knowledge that students should develop during the unit, prior to starting the actual challenge that will help in successfully, scientifically solve this design challenge, ultimately making this a valuable learning experience, is...

Students should be able to:
define energy
explain molecule movement in relation to heat energy
have a general understanding conduction, radiation, and convection
explain what colors can absorb and reflect heat energy
explain that energy will move from the hotter object to the cooler object to reach thermal equilibrium
read a thermometer
subtract
explain and use the steps of the engineering design process

Due to the nature of this type of problem solving challenge, it is an ill structured problem because of its open-ended ways. Students are asked to structure their own design, and there are endless design solutions for them to take. There is not a right or wrong answer. There will be stronger solutions due to having a larger temperature difference, but there will not be only one correct way to derive to this.

Objectives and ancillary concepts/content covered by the project

The main objective of this design challenge is to design and build a solar hot water heater. The goal is to see if the team can create a wide range from before and after the water goes through the system the students build. During brainstorming, the kids are encouraged to use the concepts of:

-colors for absorbing heat
-reducing insulating factors
-rate of time to absorb heat
-surface area as a factor for absorbing optimal heat energy

Again, these concepts will have all been explored prior to the challenge in the 5E format so that these concepts have been scaffolded and can be common set of vocabulary for the students during the challenge. They can use the knowledge to help them solve the challenge and reinforce the concepts rather than learning it for the first time.

The secondary concept that I would use to introduce this challenge is the context of astronauts using this technology on the moon. This will be used as the interest piece, but it will not be the main focus. Our focus will be the heat/energy focus. I would also like to take the time to talk about conduction, convection, and radiation. This is a developing concept, and I think the more I can expose the students to more real-life examples, the better they can feel more confident with it. But, it will not be a focus. I will be proud of my kids if they accomplish this challenge, using the science as backing, at this level described.

Possible activities to use before the challenge to prepare students

There will be several activities that I would do in more of a 5E “Explore” manner that I know are successful activities because we have implemented them in our classroom the last couple years for our energy unit. I feel that the following activities would definitely help develop the “Declarative Knowledge” needed before embarking on the design challenge. Of course, there is still the discussion and more to be done, but this is a healthy sampling of what could be done.

What is Energy?

I place several toys and items of interest at each lab table and a few at my table (wind up toys, balls, cars, *matches-my table*). I write the word “ENERGY” on the board and tell the students that all of the items illustrate energy. That is all that I tell them about the items. The students are to go to their tables and make observations in their lab notebook on each item at their lab table. They are then to try to connect all their observations in some way to come up with a definition for energy. We, as a class, ultimately create our definition for energy...the ability to cause change.

Molecule Movement

Fill one beaker with 300 ml ice water.

Temp of ice water: _____

Fill one beaker with 300 ml hot water.

Temp of hot water: _____

At the same time, add a single drop of red food coloring to the two beakers.

Does the food coloring behave the same in each of the beakers? Why or why not?

_____

_____

_____

What can you say about the relationship between heat and the movement of molecules?

_____

_____

Ice Melting Blocks - Conductors

Observe the two blocks. Do they look the same? Different?

_____

Touch the two blocks. Does one block feel cooler than the other block? _____

Place the o-rings on both of the blocks. Place an ice cube inside each ring.

Observe the melting ice cubes. Do the ice cubes melt at the same rate? Explain.

_____

_____

Temperature Conversions
(BONUS LESSON for this challenge, yet, a 4th grade science standard)

$^oF = (9/5)^oC + 32$

A. Using the above equation, convert 10^o C to ^{o}F.

B. Using the above equation, convert 68^oF to ^{o}C.

Light Energy to Heat Energy

Observe the two metal boxes. Describe any differences between the boxes.

_____

_____

Insert a thermometer into each box. What is the temperature?

White box: _____ Black box: _____

Place both boxes under the heat lamp. Wait two minutes. Now what is the temp?

White box: _____ Black box: _____

Explain:

_____

_____

Radiometer

Observe the vanes, or wings, in the radiometer. Describe the vanes. What color are they? Are they stationary or moving?

_____

_____

Now shine the flashlight on the vanes. What happens? Why?

_____

_____

Insulators

Place your hand in the ice water.

The temperature of the ice water is: _____.

Take turns placing your hands inside the blubber glove, styrofoam cup, and plastic bag. Which provided the best insulation and why?

_____

_____

_____

The best activity for the classroom

I chose *Feel the Heat* from NASA and Design Squad's "On The Moon" Design Guide. I know it is rated for grades 9-12, but I have worked with my students for the past 3 years. Looking over the lesson, I think it is rated a bit too advanced, overall. I also feel that my students are quite advanced, being gifted students, and I feel that their abilities could meet this challenge. I used to teach 6th grade, and I honestly think that my 6th graders could accomplish this challenge when we studied our energy unit after I taught the necessary concepts. Our students work at a very creative level, and we teach the energy concepts that are needed for this challenge in a very comprehensive, yet, exploratory way. I feel that this would be a great addition to our unit. I want to try it and see if it would be a good fit our our kids. There is science application, but I think the level is not too advanced with the guiding questions and first set-up that is given. I would try to run the challenge just as written, but do it in the most basic form. I would not go to the major extension ideas. I would just do the first level challenge.

https://www.nasa.gov/pdf/308966main_On_the_Moon.pdf

The lessons *Molecule Movement* through *Insulators* are courtesy of Sycamore School and Mrs. Judith Mills. She authored the lessons and forwarded the lesson write-ups that we have used for our 4th grade science energy unit.