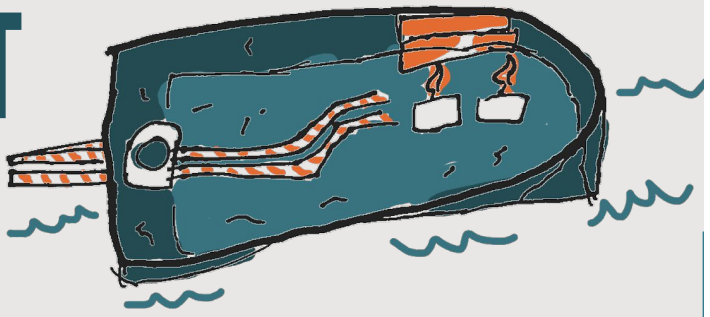
PUT-PUT BOAT

MIDDLE SCHOOL LEVEL 3



Steam engines are external combustion engines that perform mechanical functions, using steam as their working fluid. The Put-Put boat is a an experiment in steam power. Using simple materials that are easily sourced, you can build a miniature steam boat that will propel itself around a body of water.

EDUCATIONAL STANDARDS:

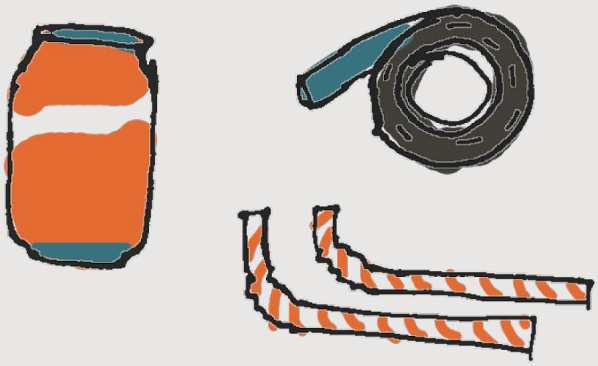
NGSS CONNECTION:

HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)



COMMON CORE CONNECTION:

ELA/Literacy

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

MP.2 Reason abstractly and quantitatively.

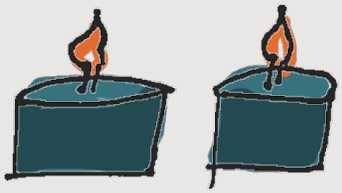
MP.4 Model with mathematics.

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

MATERIALS NEEDED:



- ❏ Tin can
- ❏ Tape
- ❏ Bendy straws
- ❏ Candles
- ❏ Homemade toy boat

DIRECTIONS:

1. Carefully, cut off the top and bottom of a tin can.
2. Cut down the side of the can to open and flatten the aluminum. Use the creases made in the can during the machining process as a guide to cut along.
3. Trim the edges of your can down, leaving a rectangle of tin about 8" wide.
4. Fold the tin in half, widthwise, so you have a 4" folded section. Apply weight evenly on the fold using a flat object.
5. Tape the open end of the folded can closed.
6. Trim the height of the folded tin to 2 ½". Keep the strips of tin for use later in the construction.
7. Use a ruler or flat object to crease the tin and bend it, widthwise, a quarter inch on both sides. Carefully work these bent parts of tin all the way over so it is folded on itself. This is the heating element for the boiler.
8. Use a pen to open up the end of the tin fold that has not been sealed.
9. Cut the bendy straws 2" from the bendy part on the long part of straw.
10. Put the cut end of the straws ⅛" into the boiler next to each.
11. Seal the boiler using glue or an epoxy. Be sure you get all the folded and open airways sealed.
12. Seal around the straws as well. You should now have a pocket of air with two straws protruding from the end.
13. When the glue has dried, attach the boiler to the back of your boat.
14. Cut ½" of birthday candle. These work well because they create a small flame.
15. Attach the candle to the deck of the boat.
16. Add a bit of water to the boiler by pouring through one of the straws until water comes out the other. This will provide moisture to make steam. While keeping a bit of water in the straws, lower them into the water.
17. Attach the boiler to the rear of the boat so it is suspended above the candle. The boiler side, with the glue and folded parts, should be facing up. The bottom should be free from any glue or tape.
18. With the boiler held in place above the candle, and the straws resting in the water, light the candle. The flame should be far enough that it is not touching the tin, but providing enough heat to steam the water in the boiler.

    As the steam builds, it pushes out the opening of the straw creating the momentum to power the boat. Priming the boiler and straw jets with water is a key part of success here. You may need to problem solve your boilers and innovate a better design. Using these directions as a starting point, you are on the path to success.

LESSON PLAN 1: HEAT VS TEMPERATURE

PRIOR KNOWLEDGE:

1. Students have studied kinetic energy in their kinematics unit

OBJECTIVE:

1. To observe and explain differences between temperature and heat

ENGAGE:

1. Teacher swabs rubbing alcohol on the back of a student's hand.
    a. "What do you observe about the alcohol?"
    b. "Is the alcohol colder than the air? How can we test that?"
    c. "Why do you think that the alcohol feels cool?" If the class has already studied vaporization, the teacher might continue the discussion comparing water and alcohol.

EXPLORE:

1. 4 containers of small materials with differing heat conduction rates are placed at each table.
    a. "Predict the temperature of each container. How do you think each will feel if you place your hand in them?"
    b. Students design an experiment and create a data table to test their hypothesis.

EXPLAIN:

1. Discuss the data with the class. Through inquiry questions, allow students to differentiate between temperature and heat. Questions can include:
    a. "Why do some materials feel cooler? How could we test that hypothesis?"
    b. "How does your brain determine hot and cold?

ELABORATE:

1. Students read the introduction and procedure for Measurement of Heat Transfer. They write their hypothesis before collecting data
2. Discuss the data with the class. Use the discussion questions to develop an understanding of the First Law of Thermodynamics.

EVALUATE:

1. Students answer the following written prompt as an exit ticket "When your mother tells you to close the refrigerator door and not 'let all the cold out,' what is not scientific about that demand? (Warning: do NOT tell your mom that.)" Draw a diagram of the thermal energy and the movement of heat energy before and after you opened the refrigerator

LESSON PLAN 2: HEAT INSULATION

OBJECTIVE:

1. To collect and analyze data on the heat conduction rate of different materials and read and interpret an article to collect evidence to support their models

ENGAGE:

1. Teacher displays a picture of an igloo made from ice and asks the class, “how do igloos keep people warm?” Students write their ideas after discussing with a partner.
2. Class discusses igloos and other examples of heat transmission in everyday life. Concept of insulation is discussed.

EXPLORE:

1. Parameters for heat insulation is discussed with the class. Teacher connects the objective of next activity, heat box, to this engineering challenge. Class is shown available materials and asked to test those materials’ ability to insulate.
2. Class collects and shares data.

EXPLAIN:

1. Students review reading: “Heat Conduction and Transfer.” In teacher-directed instruction, class reviews how to calculate heat transfer coefficient. Students complete problems in pairs.
    a. Class read and discusses article on how things work: Heat Insulation https://www.explainthatstuff.com/heatinsulation.html
2. Class discusses results of data including
    a. What materials acted as the best insulator? What qualities did they have?
    b. What other things may have affected the results? Could we control for them better?
    c. Students work in groups to develop a method to determine the heat transfer coefficient for their box.
3. Class reads and discusses article on heat insulation. Students read the article independently for the first time, circling key terms, numbering paragraphs, and focusing on graphics. In groups of four, student reread the article each for a different purpose.
    a. What does the article tell you about what would make the best insulation for your box?
    b. How is heat insulation used in everyday life?
    c. How does heat insulation work?
    d. What can you learn about key terms and ideas about heat from the article? Students fill out graphic organizer of information and evidence and location in text. As a group of four, students share their findings. The class then discusses whether the article met each of the purposes.

ELABORATE:

1. Students design a second container using the article, class data and discussion.
2. After making their second model, they test it.

EVALUATE:

1. Citing evidence for their claim: students analyze all the data collected and make a claim. They use a graphic organizer to support their claim with evidence and reasoning.

PUT PUT BOAT- SKETCH YOUR IDEAS

STUDENT HANDOUT

NAME:_____

Heat Transmission	Description	Picture	Example	Application to Your Heat Box
Conduction				
Convection				
Radiation				

PRELIMINARY PLANNING

Driving Question: How do we design a working model that demonstrates and explains three methods of heat transfer: radiation, conduction, convection?

1. List scientific topics that you will need to research in order to answer the driving question.
2. Make notes on parameters.
3. Which materials will you use and how will you use them?
4. How will the model demonstrate each type of heat flow?

Conduction	Convection	Radiation