Insulation Creations

Summary: Students test various insulating materials while trying to prevent a liquid from cooling.

Objectives

Students will be able to

- define what insulation is;
- compare the insulating capacity of various materials;
- recognize the connection between insulation and energy conservation; and
- make a connection between insulation and heat energy transfer.

Rationale

Being able to compare the insulating quality of different materials will support students in relating energy conservation and construction principles to their daily lives. Understanding and applying energy conservation is a prerequisite to the effective use of renewable energy technologies in construction.

Materials

- Small paper (bathroom size) cups
- Cardboard boxes that are all the same size (i.e. shoeboxes, tall paper juice boxes)
- Copies of ***Recording Page***
- Various materials for insulation (see ***Suggested Insulation Materials***)
- Construction materials such as tape, glue, string
- Thermometers
- Metric rulers
- Goggles and gloves (dependent on types of insulation)
- Gelatin
- Thermos
- Scissors or box cutters

Getting Ready

Prepare the gelatin and store in thermos so that it remains a liquid until students are ready to test their insulating materials.

Background

When building a home using any renewable energy system or converting an existing home to use a renewable energy system, proper insulation is essential to ensure optimal performance. Utilizing the proper amount of thermal insulation in the building envelope can help reduce cooling and heating energy demands that, as a result, will reduce CO_2 emissions into the atmosphere. In other words, insulation is important for the overall efficiency of a building and reduces the size of a renewable energy system needed for a building. Insulating a home or building well when it is constructed adds significantly to the efficiency of the building. Proper installation includes utilizing the type and amount of insulation needed to provide the strongest barrier possible, while also eliminating gaps, folds, creases, and holes in insulation.

Several materials can be used to insulate a home such as foams and padding. In certain climates, massive building envelopes such as earth and insulating concrete forms can be utilized as one of the simplest ways of reducing building heating and cooling loads. Different materials have varying resistance to heat flow. R-value indicates a material's resistance to heat flow: the higher the R-value, the more the material insulates. Home energy consultants can help decide what level of R-value is needed based on climate, home design, and other conditions. With proper insulation, savings are often achieved in the design stage of the building and on a relatively low-cost basis. When building a structure and integrating renewable energy technologies, it is important to pay close attention to the insulation methods used in order to optimize the performance of the building.

Procedure

Orientation

Ask students if they would take a long winter walk without wearing a hat and coat. Discuss how coats and hats keep people warm in winter. Discuss the common misconception among students that hats

Grade Level: 5–8

Subject Areas: Science, Technology Education

Setting: Classroom and outdoors on a chilly or cold day

Time:
Preparation: One hour
Activity: Two-three 50-minute periods

Vocabulary: Conduction, Convection, Insulation, R-value, Radiation

Suggested Insulation Materials:

- polystyrene foam (Styrofoam)
- fiberglass (use goggles/gloves)
- corrugated cardboard
- bubble wrap
- vermiculite or perlite in a plastic bag
- cotton balls/batting/material
- fiberfill (used in winter jackets)
- soft foam (used in cushions, pillows, and for packing)
- carpet padding, wool, shredded paper, soil, straw, other natural materials

Major Concept Areas:

Theme I

- Natural laws that govern energy
- Energy flow in ecosystems, including human societies

Theme III

- Quality of life
  - Lifestyles
  - Health and safety
- Quality of the environment

Theme IV

- Management of energy resource use
- Future outlooks for the development and use of energy resources

(Standards cont.)

Standards Addressed:

Wisconsin Model Academic:
SC: A.8.1, B.8.3, C.8.1, C.8.2, C.8.3, C.8.4, C.8.5, C.8.6, C.8.7, C.8.9, C.8.10, C.8.11, D.8.8, G.8.7
TE: A.8.1, B.8.4, C.8.1, C.8.2, C.8.3, C.8.4, C.8.5, D.8.2

Common Core ELA: RST.6-8.3, SL.5-8.1b, SL.5-8.1d, SL.5-8.4, SL.5-8.6, WHST.6-8.7

Common Core Math: MP4, MP6, 6.SP.5

NGSS: MS-PS3-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4
SEP: Constructing Explanations and Designing Solutions
DCI: PS3.A: Definitions of Energy, PS3.B: Conservation of Energy and Energy Transfer
CCC: Energy and Matter

and mittens provide heat by making sure students understand that our bodies generate heat and that clothing helps our bodies retain heat by acting like insulation.

Ask students how homes stay warm in winter. Help students to identify sources of heat in their homes. Explain that just as our bodies can lose heat, heat can escape from homes, too. Challenge students to list places where heat can be lost from homes (e.g., windows, doors, walls, outlets, ceiling).

Steps

1. Tell students they will be in teams and that each team will design an energy efficient home. Their challenge will be to keep the inside of the home warm. The inside air will be represented by liquid gelatin in a paper cup. Just like air that has been heated by a furnace, this gelatin has been heated by a stove. If necessary, show students how gelatin will set after it has cooled; their mission is to prevent the liquid from losing heat and solidifying. Explain that they will need to do several tasks before beginning their home construction. They will need to research various types of insulation, create a hypothesis, state a prediction, document variables and experimental design/procedure, and sketch their design with metric measurements. Explain that they will be collecting data from their experiment, comparing their data to that of other teams, and presenting their designs using their sketches as evidence to explain their project to their peers.

2. Divide the class into small teams. Provide each team with a box, an empty paper cup, and a copy of the ***Recording Page***.

3. Tell students the cup will eventually be filled with the heated “air” (the gelatin), and that they should design a way to keep the “air” in the cup warm.

4. Introduce students to the materials that are available for use in their homes. Students can bring materials from home as necessary if time permits. Students should research the insulating materials and fill in that section of their ***Recording Page*** before they begin construction. Go to the KEEP website for resources or conduct additional research. **Caution: If students plan to use fiberglass remind them to use goggles/gloves to protect their eyes/skin.** Discuss which materials they are choosing and how they are using the materials to best conserve energy in the form of heat.

5. Review the engineering constraints listed on the ***Recording Page*** and have student complete the Hypothesis, Prediction, and Variables sections.

6. Remind students that they will need to be able to open their box to take the cup in and out to periodically check the status of their “air.” Additionally, an opening for their thermometer must be provided so they can collect and record the internal termperature of their home. Hint: They can design their home so that the thermometer can be read without opening the box. For example, a window would allow them to collect observations so they do not have to continually open the box.

7. Students should sketch their home plans and then begin the actual construction. The team should divide up the jobs to make sure everything has been accomplished. One student can take and record metric measurements of the box. One student can sketch the home design and label each side with the correct measurements. Another student can begin writing the technical instructions. A set of example technical instructions may be: Step 1-Measured the length of the box. It is 25.4 cm long, 19.4 cm high, and 12.4 cm wide. Step 2-Cut a piece of bubble wrap that is 25.4 cm X 12.4 cm and glued it to the bottom of the box. Reminder: There should be one sketch for each step. Students will be using these sketches and instructions as they present their design to peers at the end of the lesson. After homes are complete, set them aside to be taken outdoors the following day or when time permits.

8. After students have dressed for the outdoors, take them outside and have them line up their homes containing empty cups. Fill each cup with the hot liquid gelatin from the thermos and tell students to quickly, but carefully, “close” their homes. **Caution: Warn students that the gelatin is very hot**. Also, be sure that all boxes are sitting on the cold ground. Having a piece of cardboard, a blanket, or other material under a box will help prevent conduction and would be an additional variable.

9. Have students test their homes’ heat retention abilities and record their results on their ***Recording Page.*** Take the temperature (quantitative data) and visual observation (qualitative data)

every three minutes, recording when the gelatin becomes solid. Encourage students to use words like “thickens”, “coagulates”, and “firm” in their descriptions. Once the gelatin solidifies, students should stop taking data.

10. Students should complete the ***Peer Discussion Questions***. They should also compare data with at least one other team. Teams can also create charts or graphs to show their data (time on the X axis; temperature on the Y axis).

11. Have the students present their results to the class. Each team should show their design sketches, and graphs if applicable, to their classmates explaining the type of insulation used and describing both the qualitative and quantitative data collected. Based on their evidence, students should provide a concluding statement as to whether or not people should use the specific type of insulation selected for their homes.

12. After all teams have presented their designs, have a large group discussion and ask the students to suggest ways to improve their designs in order to keep their “air” warmer longer. Refer back to the ***Recording Page*** and discuss the answers to the questions.

Closure

Discuss various types of insulating materials commonly used in homes and buildings. Have students list reasons why insulating buildings is important. Discuss how insulation affects the energy efficiency of a building.

Assessment

Formative

- How well did the students conduct their experiments? How well did they work as a team?
- What insulation materials can they list that appeared to be most effective?
- How thoroughly and accurately did students complete their ***Recording Page***?
- How thorough and accurate were the students’ responses during the large group discussion?
- How well did the students present their data, explain their house construction, and use evidence to explain why their insulation was or wasn’t effective against heat energy transfer?

Summative

Ask students to research three types of insulation used on houses. Based on their findings from the experiment, which of the insulation types would they recommend? Why?

Extensions

Allow students to experiment with various weather stripping and caulking materials in an activity similar to the above. Explain to the students how this can be used in conjunction with insulation to reduce the leaks and drafts in a home.

If installing passive and active renewable energy systems to heat homes has already been studied, challenge students to explain why homeowners might want to ensure their homes are well insulated before installing these systems.

Have students ‘test’ the air tightness of their box by placing a feather on top of the gelatin container. Close up all the boxes and place a fan approximately 3 inches away from the first box. Turn on the fan for 30 seconds. Turn off the fan. Open the box. Has the feather remained in place? Test all student boxes. Have students discuss why some feathers were displaced while others remained intact.

Have students extend their understanding of insulation by researching R-values of different materials. See if they can determine the R-value of insulating materials used around their home or school.

Change the experiment to be completed during the warm season. Instead of trying to keep the heat in the house, try to keep the cold in the house. Switch out the gelatin and use an ice cube. Make sure all cubes are the same size. Place the cube into the cup. Take the temperature every three minutes. Use a pipette to remove any liquid from the cup. Measure that water in a graduated cylinder and document the amount of ml on your observational chart.

Social Studies connections: People around the world use the materials they have available to them in their surrounding environment to insulate their homes. Snow and ice can be insulators in the Arctic. Brick and adobe are used in the hot and arid regions and the thickness of those materials have an effect on how cool the homes remain. Trees provide shade for homes which help temperatures to remain cooler.

Final Connection

Use this activity to provide a basis for thinking about energy conservation through utilization of insulation techniques. Then, challenge students to incorporate what they have learned in the cumulative project, “Green Home Design.”

Recording Page

Building Criteria and Parameters

Engineering Constraints:

- You may only select one kind of insulation.
- Added materials should not exceed 2.54 cm (1 inch) thickness. Remember you are insulating a home—leave room for the furniture!
- All materials must be installed inside the box.
- No heat source may be added to the inside (e.g. hand warmers, flashlights).
- The “air” (cup with gelatin) must not touch any materials on the sides or top when placed in the box.

PROBLEM:

How can we properly insulate our shoebox house so that the gelatin will not solidify when placed in a cold environment?

RESEARCH:

List your building materials below and any data you’ve collected about these materials through your research.

Why do you think these materials and design will help your “home” retain heat?

Include the approximate R-value of your insulating materials below.

HYPOTHESIS:

Write your hypothesis using the words "if", "then", "because." Example: If I use the styrofoam, then I think the gelatin will not solidify because it is very dense and has a fairly high R-value.

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PREDICTION:

Provide a prediction of how long you think it will take the gelatin to set? ________ minutes

VARIABLES:

What is the control in your experimental design? ____

What is the independent variable(s) in your design?____

What is the dependent variable(s) in your design?____

PROCEDURE:

Write each step involved in insulating your house on a blank piece of paper (example: Step 1-measure the walls of the box). Also, draw a series of sketches, complete with metric measurements, which illustrate all of the dimensions. You can use this information when you discuss your project during the peer review/presentation.

QUALITATIVE AND QUANTITATIVE DATA CHART

**Length of time to solidify will be dependent on current weather conditions/temperatures outdoors.*

**Look under extensions to see how you can change this activity during the warm months by using an ice cube instead of gelatin.*

Qualitative Data (what the gelatin looks like)		Quantitative Data (temperature of the box)
Write Start Time Here:		
3 minutes		
6 minutes		
9 minutes		
12 minutes		
15 minutes		
18 minutes		
21 minutes		
24 minutes		

Compare your data with another team that used a different kind of insulation. What did you discover?

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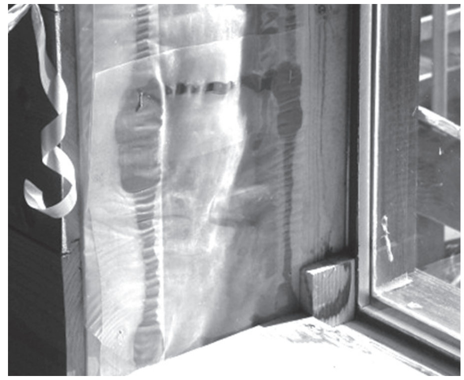

Peer Discussion Questions

For the questions below, do your best to explain what you know about heat energy transfer and how it might have been applicable to your construction project. Explain all answers in detail.

1. Where was conduction happening in this project? ______________________

2. Where was convection happening in this project? ______________________

3. How was radiant energy involved in this project? ______________________

4. Was your hypothesis correct? ______________________

5. Was your prediction correct, close, or off the mark? ______________________

6. Using your data and the comparison data from one or more teams, explain what you discovered about the different kinds of insulation available for this project. ______________________

7. Do you think the type of material used makes a difference in the amount of time it takes for the liquid to cool and solidify? ______________________

8. What material do you view as most effective at conserving energy or heat in your box home? ______________________

9. What would you do differently if you were to redesign your building? ______________________

10. Thinking about heat energy transfer, what else would you like to change about your experiment that might impact the results you observed? ______________________