StarCups Challenge: Keep It Hot Like a Barista!

Keeping It Hot: Exploring Energy Transfer and Insulation

Grade Level: Middle School
Time Required: 90 minutes

NGSS Standards

- **MS-PS3-3**: Apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer.
- **MS-ETS1-1**: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.

Lesson Objectives

- Understand how heat energy is transferred through conduction, convection, and radiation.
- Explore the properties of insulating materials and their ability to minimize heat loss.
- Design and test a cup that keeps a hot beverage warm for 5 minutes with a maximum temperature drop of 2°C.

Materials *(per group)*

- Various materials for insulation (felt, foam, aluminum foil, cotton, bubble wrap, etc.)
- Plastic or paper cups
- Thermometers
- Hot water or prepared hot chocolate/coffee
- Stopwatch or timer
- Measuring cups (for consistent liquid volume)
- Scissors and tape
- Data recording sheets

Procedure

1. Introduction (15 minutes):

- **SET UP:** Create a coffee shop out of your classroom and serve hot chocolate.
- **Hook:** Ask students what they do to keep drinks like hot chocolate warm on a cold day.
- Explain the concepts of **energy transfer** (with a focus on conduction) and **insulation**.
- Discuss real-world applications, such as thermos bottles or insulated mugs.

- Introduce the challenge: design a cup to keep hot chocolate from losing more than 2°C over 5 minutes.

2. Planning Phase (20 minutes):

- Divide students into small groups.
- Provide them with the list of materials and the design constraints:
    - The cup must hold 200 ml of liquid.
    - Only provided materials can be used.
    - The design should be safe and stable.
- Students sketch their cup design and list the materials they plan to use.

3. Building Phase (20 minutes):

- Students construct their insulated cups based on their designs.
- Teachers circulate to offer guidance and ensure safety.

4. Testing Phase (20 minutes):

- Fill each group's cup with 200 ml of hot water or hot chocolate (at a standardized temperature, e.g., 60°C).
- Insert a thermometer and record the starting temperature.
- Wait 5 minutes, then record the final temperature.
    - During the 4-minute period, have them write down observations of their container. and the water.
    - You could also have them graph the data.
- Calculate the temperature change and determine if the design met the 2°C drop constraint.

5. Reflection and Discussion (15 minutes):

- Have each group share their results, explaining what worked well and what could be improved.
- Discuss which materials were most effective and why.
- Relate their findings back to real-world insulation products.
- Hang results on the wall and have the students gallery walk and discuss everyone's prediction and results.

Assessment

- Students will be assessed on:
    - Their understanding of energy transfer and insulation (verbal or written responses).
    - The effectiveness of their design.
    - Group collaboration and creativity.

Extension Ideas

- Challenge students to improve their designs after initial testing.
- Introduce variables such as testing with colder starting environments or different liquids.
- Discuss the environmental impact of disposable cups and brainstorm sustainable alternatives.

Picture from: https://www.axios.com/2024/11/13/starbucks-free-red-cup-day-2024-holiday-drinks

Keeping It Hot: Energy Transfer and Insulation

Group Name: _____

Team Members:

_____

Date: _____

Part 1: Planning Your Design

1. Sketch Your Design
Draw your cup design below. Label the materials you will use for insulation:

Sketch area

2. Materials List
List the materials your group will use for your insulated cup:

Material	Quantity Needed	Purpose (e.g. insulation, structure)

Part 2: Prediction

What is your predicted temperature drop after 5 minutes? (in °C):
Prediction: _____°C

Why do you think your design will be effective?

Write your explanation here:

Part 3: Testing Your Design

Follow these steps to test your cup:

1. Record the starting temperature of the liquid.
2. Wait 5 minutes.
3. Record the final temperature.
4. Calculate the temperature change.]

Observation:

Testing Data Table

Test #	Starting Temp (°C)	Final Temp (°C)	Temp Change (°C)	Met the Goal (Yes or No)

Part 4: Reflection and Improvement

1. What worked well about your design?

Write your answer here:

2. What would you change to improve your design?

Write your answer here:

3. Which materials were the most effective and why?

Write your answer here:

Extension Question

If you had to design an insulated cup for a company, what advice would you give them about material choice and design?

Write your answer here: