DESIGN A METHOD TO CHANGE THE RATE OF **HEAT TRANSFER**

STUDENT HANDOUT

Utah SEEd Standard 6.2.4
Next Generation Science Standard: MS-PS3-3
Grade and Topic: 6th-grade Integrated Science
Middle School Physical Science

THE UNIVERSITY OF UTAH
College of Education

UTAHFORGE
U.S. Department of Energy

Why does an Ice Cube Melt?

Name _____

Do this:

- Observe the ice cube melting in your glass.

Draw this:

- Draw a picture of the ice cube as it is melting.
- Draw the things that are happening inside and around the ice cube that makes the ice cube melt.

Discuss this:

- What do you notice about the ice cube?
- What do you think is happening to cause the ice cube to melt?
- What do you think is happening in and around the ice cube as it is melting?

Station 1: Observing Conduction

Group Members _____ _____

_____ _____

Conduction is when heat is transferred through direct contact. In other words, heat moves from one object to another object because they are touching.

- How does each of the beakers feel when you touch them?

- How does this demonstrate conduction?

  How do you know?

- When touching the hot beaker, which way does the heat flow? (From the beaker to your hand or from your hand to the beaker.)

  How do you know?

- When touching the cold beaker, which way does the heat flow? (From the beaker to your hand or from your hand to the beaker.)

- What is another example of conduction?

Station 1, cont.: Is it a Conductor? or is it an Insulator?

Conductors are materials that allow heat to flow through the material. Insulators stop the flow of heat through the material.

- Which items are conductors? Which items are insulators?
- What patterns do you notice?
- What do you think makes a material a good conductor?
- What do you think makes a material a good insulator?
    - Circle the item you think is the best conductor.
    - Circle the item you think is the best insulator.

Station 2: Observing Convection

Group Members _____ _____

_____ _____

Convection is heat transfer through the movement of fluids. Convection can be forced, like when the furnace blows hot air. Convection also occurs naturally when a fluid is heated from below. This causes the hot fluid to rise, pushing the water above it out of the way, and pulling in the water from the side. As the hot water rises, it cools, which makes it fall back to the bottom ...and the cycle repeats…

- How does this demonstrate convection?

- Which direction is heat being transferred or moved by the water in this beaker?
    - How do you know?

- What is another example of convection?

- What if you wanted to make the heat flow from one object to the other faster? For example, if you wanted to cool your computer or cool cookies you are baking?

- What if you wanted to prevent the heat from flowing from one object to another? For example, if you wanted to stay warm while snowboarding or you wanted to keep your hot chocolate from getting cold?

Cool fact: You get goosebumps when you are cold in order to make your hair “stand on end.” This reduces the air flowing over your body and helps prevent heat from being lost through convection. A wet suit is also designed to reduce convection near your body, this time between the water and your body. By preventing the water from flowing over your body, you are able to stay warm in cold water, even though you are wet

Station 3: Observing Radiation

Group Members _____ _____

_____ _____

Heat is transferred by radiation in the form of infrared light. All things lose energy by radiating that energy away. Heat is transferred when that energy is in the form of infrared radiation. This is how IR cameras and night vision goggles work.

- How does this demonstrate radiation?

- What is another example of radiation?

- Which direction is heat being transferred or moved by the heat lamp?

How do you know?

Cool fact: Our bodies have neurons that can detect heat being transferred through infrared radiation. This is how you know that something is warm or that something is hot without actually touching it. This is why you can warm your hands by holding them near a fire.

Station 3, cont.: Changing the Radiation

Different materials can affect how much heat is absorbed. Some colors absorb more heat, other colors absorb less heat. Some materials reflect radiation. You can change how much radiation is being absorbed by placing different materials in front of or behind the object.

- List the items that caused the water to **heat up more**:
    - Materials **underneath** the beakers of water:
    - Materials **in front of** the beakers of water:
- List the items that caused the water to **heat up less**:
    - Materials **underneath** the beakers of water:
    - Materials **in front of** the beakers of water:
- Are some items on **both lists**, but **behind** the beaker of water on one list and **in front of** the beaker of water on the other list?
- What patterns do you notice?
- Why do some materials make the water hotter and some materials keep the water cooler?

Beginning the Engineering Process: Designing a Method to Reduce Heat Transfer

Group Members _____ _____

_____ _____

In this part of the lesson, you are going to engineer a solution to keep the ice cube from melting. We have already defined the problem and identified criteria and constraints. Now you are going to brainstorm some ideas for how you can solve this problem. When you are done brainstorming, your group is going to decide which method to construct using a consensus-building process.

Engineering Process:

1. Define the problem: **How can we prevent our ice cubes from melting?**

2. Identify criteria and constraints:
    - Criteria: **The method needs to keep the ice cube from melting.**
    - Constraints: **We need to use the materials provided.**
    - Write any additional criteria and constraints here:

3. Research the problem: We already know the three ways that heat is transferred. Think about the materials that reduced heat flow the most for each process. Then think about how you can combine them to keep the ice cube from melting.

    Conduction:
    - What types of materials worked best to prevent conduction?

    - Why do you think these materials don't allow heat flow?

- Which materials do you want to use in your design?

Convection: We didn't research how to reduce convection, but you might have some hints from reading the instructions for that station. Engineers prevent air from moving by making a layer of styrofoam, or fluff, or similar.

- Why do you think these materials don't allow heat flow?

- Which materials do you have that might help prevent convection?

Radiation:

- What types of materials worked best to prevent radiation?

- Why do you think these materials don't allow heat flow?

- Which materials do you want to use in your design? Consider using more than one layer.

4. Develop possible solutions
    - Brainstorm ideas: Spend 5-10 min in your group brainstorming ideas. Write your ideas here. Use additional paper if needed.

    - Select the best Idea: To do this, you are going to use the consensus-building process. Once you have agreed on a design, draw it here. Then get your teacher's approval for your design

Teacher approval _____

Get teacher approval before beginning the next step.

Selecting a Design through Consensus

Because you will be working as a group to create your method of preventing the ice cube from melting, you need to all agree on the design. In this process, you are going to give an initial proposal for which design your group should build. Next, you will discuss the proposals. After this, you will vote on the proposals. If you have consensus, you can move to the next phase. If you do not have consensus, you will return to discussing the proposals.

Initial Proposal

Each group member should begin their proposal with this statement:

I propose that we build _____ design. This design reduces heat transfer from conduction by _____, it reduces convection by_____ and it reduces radiation by _____. Also, we have the things we need to build this, and we can build it in the time we have.

Talk Moves to Come to Consensus

Next, as a group, you need to come to consensus about which design to build. Coming to a group consensus can be challenging. It is important that everyone's voice is heard and their opinions are respected. By listening to each other, it is possible for everyone to be able to agree on the final decision. Here are some talk moves to help you express your opinion and listen to your group members.

I agree with building _____ design because this will prevent the ice cube from melting..
I agree with building _____ design because we have the things we need to build this, and build it quickly.

I disagree with building _____ design because this will not prevent the ice cube from melting.
I disagree with building _____ design because we don't have the things we need to build this, and we can't build it quickly.

I am undecided about building _____ design and would like more information on why this would be a good design to build.
I am unsure about building _____ design because I have concerns about _____. How can we address my concerns?

Consensus Voting

In consensus voting, group members signal their vote with their thumbs.

- Thumbs-up indicates “yes, I want to do that!”
- Thumbs-down indicates “absolutely not! I will never do that!”
- Thumbs-sideways is “I’m not enthusiastic about that, can we talk about my concerns?.”

If a vote has any thumbs-down or thumbs-sideways, the discussion must continue with students presenting their arguments.

Deciding on a Design

Once the group has reached consensus, the teacher will sign off on the problem and students can continue on the next step.

Continuing the Engineering Process: Building and Iteratively Testing a Method to Reduce Heat Transfer

Group Members _____ _____

_____ _____

Now that you have decided on which design to build, you are going to build it, test it, record the results, modify it, test it again, record the results, etc. After you have done the required number of iterations, you can decide which version worked best, and build (or rebuild) that version to use in the “ice cube not-melting” competition.

Engineering Process, cont.:

4. Develop possible solutions, cont
    - Build a prototype: Obtain the materials you need from your teacher to begin building your prototype, then build your prototype. Once it is built you can begin the iterative testing process.

5. Analyze data to make improvements from iteratively testing solutions.
    - Obtain a heat lamp and an ice cube to test your prototype.
    - You might want to use a scale to measure the mass of your ice cube before and after the test, so you know which test was best.
    - Place the ice cube in your device.
    - Place the device in front of the heat lamp. Record the distance to the heat lamp, you want each test to be at the same distance.
    - Turn on the heat lamp. Leave the heat lamp on for ~5 min. Decide how long exactly you want to leave the device in front of the heat lamp. You want each test to last for the same amount of time.
    - Take the ice cube out of the device.
    - Record how effective the device was at keeping your ice cube from melting.

    - Once you have completed the testing on your prototype you are going to modify one part of the device, and retest (with a new ice cube). You will need to repeat this process at least 3 times for each modification.

6. Choose the best solution, and build (or rebuild) that one!

Iteratively Testing:

1.0 – Initial test: This is the test of your prototype.

Results:

1.1 – First iteration: This is the first change you made to the prototype. Record the change here:

Results:

1.2 – Second iteration: change the same thing as before in a different way. Record the change here:

Results:

1.3 – Third iteration: change the same thing as before in another way. Record the change here:

Results:

Repeat: Use additional pages as needed.

- When you are satisfied with that modification, select a different part of the prototype to test, and repeat the testing process. Use additional pages as needed.

2.1 – First iteration of second modification: This is the first change you made to the modified prototype. Record the change here:

Results:

2.2 – Second iteration: change the same thing as before in a different way. Record the change here:

Results:

2.3 – Third iteration: change the same thing as before in another way. Record the change here:

Results:

Repeat: Use additional pages as needed.

- When you are satisfied with all your changes, pick the solution you made that works best.

Which solution did you choose? Build (or rebuild) this device to use as your “ice cube not-melter” in the competition.

Completing the Engineering Process: Communicating your Results

Group Members _____ _____

_____ _____

In the final step of the engineering process, you will be communicating your results as part of a design competition to see which method is most effective in stopping heat transfer and keeping the ice cube from melting.

Engineering Process, Cont.:

7. Communicate the results. In this step, you need to make a short presentation to share with your classmates.

Presentation Requirements:

- Title:
  - Name of your presentation
  - Names of all your group members
- The Device: This is the star of your presentation! Make it be center stage!
  - Picture or drawing of your device
- Description of Device:
  - How did you build your device?
- Reducing the Heat flow:
  - How did you reduce heat transfer through Conduction?
    - How does that prevent heat flow by conduction?
  - How did you reduce heat transfer through Convection?
    - How does that prevent heat flow by convection?
  - How did you reduce heat transfer through Radiation?
    - How does that prevent heat flow by radiation?
- Make your presentation on a poster or computer as instructed by your teacher.
- Be ready to share your presentation with your classmates.