

SCIENCE FAIR CENTRAL

Maker Corner Activity



HOT! HOT! HOT!

Grades 6-8

MAKE. CREATE. EXPLORE.

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People around the world rely on cold drinks for refreshment and hot drinks to warm up.

Overview

Every day, people around the world rely on cold drinks for refreshment and hot drinks to warm up. Homes, stores and restaurants currently have cups designed to keep beverages hot and cold—but could you do better? In this activity, students will design and build a beverage cup insulator with the goal of keeping a hot drink the warmest. They will also experiment with the fastest way to cool a beverage, using a thermometer and trying a variety of cooling techniques. After analyzing their results, students will share their findings in a one-minute public service announcement.

Have you ever wondered . . .

Why liquids have to eventually cool down?

There are three main reasons why any liquid, in a regular cup, will eventually move towards room temperature. Even a boiling cup of water and a block of ice will eventually reach the same temperature, thanks to heat transfer. (Heat transfer is the process by which heat, a form of energy, flows from a body of high temperature to a body of low temperature).¹ Using a cup of hot chocolate as our model, let's think about how this drink would cool down naturally:

This activity focuses on the **Designing Solutions, Creating or Prototyping, Refining and Improving, and Communicating Results** stages of the Engineering Design Cycle.

Engineering Design Cycle

- Defining the Problem
- **Designing Solutions**
- **Creating or Prototyping**
- Refining or Improving
- **Communicating Results**

Objectives

Students will be able to:

Create and **test** ways by which to insulate and cool a beverage.

Compare the results of their designs and evaluate the best way insulate and cool a beverage.

Present their findings and **defend** why their design is effective.



What can you do to keep your drink at the perfect temperature?

Materials

One per student group:

- Thermometer

For the class to share:

- Paper cups
- Aluminum Foil
- Bubble Wrap
- Cloth
- (4) Cardboard
- (2) Foam
- Plastic Wrap
- All Purpose Glue
- Super Glue
- Rubber Bands
- Scissors
- Clear Packaging Tape
- Duct Tape

Put the following materials to the side, as they are specifically for Part 2:

- Ice
- Table Salt
- Paint Bucket, one per student group

1. Conduction: This kind of heat transfer occurs during physical contact. When hot chocolate is heated, its atoms begin to move quickly. They collide both with each other and with the side of the cup. As hot chocolate atoms collide with the side of the cup, the atoms transfer heat to the cooler cup and the liquid cools. Heat transfer always occurs from hot to cold and not the other way around.^{2,3}

2. Convection: Heat also gets lost through convection currents. Hot air (and hot liquid) rises and cold air (and cold liquid) sinks. When you have an open cup of hot chocolate, the air just on top of the beverage becomes warm through heat transfer from the hot chocolate. You can tell this is happening because you see steam: evidence that heat is transferring from the liquid to the air and thereby cooling the drink!

3. Radiation: Radiation travels in energy waves which we can feel, but can't see. Picture the sun: The sun radiates heat, which travels to Earth in energy waves. These energy waves then deposit heat into objects, and we can feel this warmth. Radiation heat transfer is more prevalent in extremely hot objects like burning metal and electric heaters, but it can also account for a little bit of hot chocolate's heat loss.³

What can you do to keep your drink at the perfect temperature no matter the weather?

There are certain materials that act as insulators, which means that they stop and/or slow the flow of electrons from atom to

Even a boiling cup of water and a block of ice will eventually reach the same temperature.



atom. An insulator therefore stops and/or slows the heat transfers that are described above. Other materials act as conductors, which mean they allow electrons to travel easily from atom to atom, which allows heat transfer to occur.⁴ Because these two types of materials exist, there are some materials that are better than others at keeping a beverage warm. By testing materials that best keep a cup of liquid warm and by also testing how to best cool a liquid, you will soon know how to keep your drink at the perfect temperature all year long!

Make connections!

How does this connect to students?

Have you ever been playing sports and had to drink a warm sports drink? Or sipped on your hot chocolate in the middle of winter only to find that it was freezing cold? Imagine what it would be like to know how to best keep your drink at the perfect temperature!

How does this connect to careers?

Thermal Physicist—While all physicists study the atoms that make up our world, thermal physicists study the specific relationship between temperature, heat, work and energy.⁵

Mechanical Engineer—A mechanical engineer uses concepts of heat and energy to design everything from aircrafts and industrial equipment to heating and cooling systems.⁶

Packaging Engineer—Packaging engineers focus on developing and optimizing protective packaging for beverages, as well as fruits, vegetables, toys, and other goods.⁷

How does this connect to our world?

Different cultures appreciate a wide variety of beverages.

Countries around the world have their own versions of refreshing cold drinks: from India's Lassis to Thai Iced Tea and coconut water in tropical climates.

Hot drinks, regardless of the culture, are also associated with many rituals: from waking up, to spending time with loved ones, to lulling you to sleep. In Ethiopia, for example, the process of coffee-making often takes more than an hour and everything from toasting the bean to boiling the coffee is done tableside.⁸ In Cuba and Brazil, warm coffee with milk is enjoyed even by children for breakfast.⁹

Since so much of our world's culture revolves around beverages, you will use this activity to figure out how to keep them at the perfect temperature!



Blueprint for Discovery

Prior to the Class Arriving:

- On a white board or a large piece of paper, write in big letters: “Favorite hot drink?” Make sure there are markers available so several students can answer at one time.
- Photocopy the Hot! Brainstorm + Data Sheet, one per group of four students.
- Display the insulator materials in an area of the room that is easily accessible to students. Keep the cooling materials separate.

During Class:

1. As students enter, invite them to answer the question on the Class Graffiti board with words or a quick sketch.

2. Think/Pair/Share: Why do all of these hot drinks eventually cool down?

3. Share this [Doodle Science](#) video. (You may want to click Settings and reduce the speed to .75. The presenter speaks quickly!). **Ask:** Which of your ideas were correct? Which ideas from the video are new?

Part 1:

1. Explain that students will be having a friendly group competition to see who can create the best hot beverage insulator for a paper cup. To do this, students will be divided into groups of four. Each group will have 45 minutes to complete the Brainstorm + Data Sheet and use the materials available to create three different trial insulators. Encourage students to be creative: The sky's the limit!

2. Pass out one Brainstorm + Data sheet to each group. Review the sheet's directions, briefly introduce the available materials, and clarify any questions before students begin.

3. Provide students with updates indicating how much time they have left throughout the brainstorm, design, and building process. After about 15 minutes, encourage students to move to the building phase if they haven't already.

4. Once 45 minutes is up, direct student groups to elect a time keeper and a temperature reader.

5. Fill the student's cups with hot water. (If an electric hot water heater is available to you, you may use that, or hot water from the sink will work as well.) As each cup is filled, groups should record the water's starting temperature on their data sheet.



6. The time keeper and temperature reader should **make sure the cups' temperatures get measured and recorded consistently over the next 30 minutes**. Note: If time allows, there is also space on the data sheet to record data for longer than 30 minutes.

Part 2:

1. As the timekeepers are watching the clock and the temperature readers are doing their job, **shift the class's attention** towards the opposite of keeping something hot: cooling it down!

2. **Task the same student groups** with creating an experiment that tests methods that cool a beverage the most quickly. To do this experiment, students may use the paper cups, cold water, ice, table salt, buckets, and a refrigerator (if one is available). You may want to write these materials on the board as a reminder.

3. **Encourage students** to use the insulator experiment as a model and task them with designing the constraints and data collection for this second experiment. Allow them approximately 30 minutes to complete this experiment, and rotate throughout the classroom to provide assistance as needed.

Part 3:

1. Once students have the results of their insulator and cooling experiments, it's time to **analyze and share their findings!** Student groups should:

- a) Take time to look at their results and discuss why different designs performed in different ways.
- b) Work together to explain their findings in a public service announcement (PSA) that alerts the public of how to best cool a beverage as well as how to best keep a beverage warm. Each short presentation should explain why their warming/cooling design is effective. PSA's should be no longer than one minute in length.

If time allows, students may present their PSAs to the class or they may be recorded on a smartphone and shared at a later time.

Take Action

Possible Extension Activities:

1. Students can use what they learned about beverage insulators to create actual insulators that they can sell for a good cause. Students can think about how to design their insulator to make it appealing (colors, patterns, etc.). Groups could even create a marketing plan to help them earn the most possible money for their chosen cause!



Teacher Guidelines:

Students may wish to design their own hydroponic system and develop a plan to monitor their system. Listed below are directions for one method students could use to set up a hydroponic growing system:

1. Students should **open their plastic bin and get out their air pump** with tubing and their air stone.
2. The **air stone should be connected** to their air pump with tubing and the air stone should be placed in the bottom of their plastic bin.
3. **Set 1 net pot in down into each of the holes** that have been cut in the lid of the plastic bin.
4. **Run the tubing** connecting the air pump and air stone out through one hole that does not have a net pot in it.
5. **Use a hose to fill the plastic bin.** There should be enough water so that each of the net pots is filled with roughly $\frac{1}{2}$ " of water so that the water will reach the plant's roots.
6. Now **add nutrients to the water.** Follow the instructions on whatever liquid plant nutrients are being used, such as Black Magic A and B base nutrients.
7. **Conduct a pH test** using a pH test such as the ones used to test pools and hot tubs. The optimal pH for the water in the hydroponic system should be between 5.8-6.2. If the pH is too high or too low, add a product such as Black Magic pH UP or pH DOWN to adjust it. (Follow the instructions on the containers.
8. **Rinse the growing medium with water** to make sure it is clean (clay pellets, viastone, etc.) and fill each of the net pots with the growing medium and one of the plant starts that has been grown by the teacher.
9. **Plug in and turn on your air pump** and make sure that the hydroponic system has been setup somewhere with an adequate source of light - in a school greenhouse or under artificial grow lights.



2. To gain a global perspective, students can use the internet to research where hot and cold drinks are culturally important around the world. Students can search for explanations of why these beverages are important and what people in these cultures do to keep their drinks hot and/or cold.
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National Standards

Science

Next Generation Science Standards

MS-PS3-3-Energy

Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-ETS1-1 Engineering Design

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Engineering Design

Evaluate competing design solutions based on jointly developed and agreed-upon design criteria using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-4 Engineering Design

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Technology Education

Next Generation Science Standards and International Technology and Engineering Educators Association

Students will develop an understanding of Design. This includes knowing about:

- Attributes of design.
- Engineering design.
- The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.



Mathematical Practice

Common Core

CCSS.Math.Practice.MP1

Make sense of problems and persevere in solving them.

CCSS.Math.Practice.MP4

Model with mathematics.

CCSS.Math.Practice.MP5

Use appropriate tools strategically.

English Language Arts

Common Core

CCSS.ELA-LITERACY.CCRA.SL.4

Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

CCSS.ELA-LITERACY.CCRA.SL.6

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

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Hot! Hot! Hot! Brainstorm & Data Sheet

Directions: In the grid below, brainstorm the materials and design of your insulators as well as a brief description of why you think each insulator will be effective. There are 4 brainstorming slots in case you would like to brainstorm an extra idea and then narrow them down to three.

Materials Needed:	Sketch of the design:	Why do you think this design may work?	Temperature Trials	
Idea #1			0 minutes	°F
			10 minutes	°F
			20 minutes	°F
			30 minutes	°F
			___ minutes	°F
			Total change	°F

Idea #2			0 minutes	°F
			10 minutes	°F
			20 minutes	°F
			30 minutes	°F
			___ minutes	°F
			Total change	°F

Idea #3			0 minutes	°F
			10 minutes	°F
			20 minutes	°F
			30 minutes	°F
			___ minutes	°F
			Total change	°F

Idea #4			0 minutes	°F
			10 minutes	°F
			20 minutes	°F
			30 minutes	°F
			___ minutes	°F
			Total change	°F

