Lesson: Can You Make It Warm? Keep it Cool!

Grade Level: 6-9 – Time Required: 60 minutes.

Subject Areas:

- Science
- Physical Science

Acknowledgments

I would like to acknowledge the author(s) of Hands-On Activity: Hot Cans and Cold Cans found on teachengineering.org. I based the structure of my lesson and found inspiration from the article written by Mary Hebrank.

Summary

In this activity, students have to apply radiation and conduction principles and concepts while working in teams. They will face 2 problems: how to keep water in a can warm and how to cool down water in another can. Students will have between 20-30 minutes (teacher decides) to cool the water as much as they can. They will have access to simple materials and the internet to do research and find the best most viable solution to accomplish this goal. Teams will be provided with thermometers for them to test their progress every 5 minutes. To accomplish this goal, students will have to use the engineering Design Progress to create the best solution to this problem.

Engineering Connection

Engineers face temperature problems in a daily basis. Not only to heat or cool liquids, but also to control temperature in places or constructions. Having this in mind, students will do this activity thinking as engineers using physics knowledge as well as the engineering design process steps *(Define the problem, identify constrains and limitations, brainstorm solutions, selection the best options, prototype your solution, test and evaluate, iterate, and communicate your solution.)*

Learning Objectives

After this lesson, students should be able to:

- Explain and list the steps of the Engineering Design Process.
- Identify and analyze possible solutions to a problem.
- List good examples of materials that can be used as heat conductors.
- Identify ways to prevent materials from cooling.
- Identify ways to make materials cool using simple materials.

Educational Standards

- International Technology and Engineering Educators Association – Technology

    - Students will develop an understanding of the attributes of design. (Grades K-12)

- MS-ETS1-4
    - 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. (Grades 6 - 8)
- MS-PS3-4
    - Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (Grades 6 - 8)

Materials

- 4 12-oz cans (2 for challenge, 2 for controls)
- Thermometer
- Scissors
- 1 bottle of glue
- 1 Invisible Tape
- Construction Paper
- Fabric Scraps
- Foam
- Rubber Tubing
- 1 Straw
- Aluminum Foil
- 1 Ziplock bag
- 1 Hot Glue gun
- Glue Sticks
- Any extra material that you consider are good insulators or conductors.

Lesson Background

To succeed in this activity, it would be good that students know and understand concepts of conduction, isolation, and basic physics laws. They should also be able to read a thermometer.

Introduction

In engineering, understanding, and applying concepts involving heat transfer and temperature conductions is essential for many reasons. It allows us to comprehend physical, chemical, and biological processes that occur in a daily basis, as well as to allows us to create and think of technological solutions to different problems. For you to have a clear concept of what conduction and isolation mean, we can do a simple demo. (put 2 spoons – one metal and one wooden – directly to flames or above it and see which spoon gets hot and which one stays cold) You can use this video (**Heat Conductivity – spoon Test by Next Generation Science)** as a reference. As you can see, the metallic spoon got hot/warm fast. That is because metal spoons are good heat conductors, while the wooden spoon did not get hot because wood is a good heat isolator.

Today, you will act as if you were engineers and will use the engineering design process as well as you physics knowledge to design a solution to the challenge you will face. How would you keep one can of water as warm as possible and how would you cool a different can of water as much as you can?

I will provide you with 2 can that are filled with warm water. For 30 minutes, you will have to check the temperature of each one of the cans. One of them, at the end of the 30 minutes, will have to be as warm as possible, while the other can will have to be as cold as possible. To control the variation of temperature, you will have 2 control cans that will be used as a reference and a thermometer to monitor the temperature change of each one of the cans. You will have to use different materials to achieve the goal of this challenge.

Procedure

Before the Activity:

- Introduce the Engineering Design Process
    - Explain to the subtends the meaning of each one of the steps: *Define the problem, identify constrains and limitations, brainstorm solutions, selection the best options, prototype your solution, test and evaluate, iterate, and communicate your solution.)*

Part 1: Design of the Systems

1. Gather all the materials and tools that the students might need and place them on the desk.
2. Have students analyze, examine, and talk among their peers to do research.
3. Give students some time to complete to first steps of the Design Process.
4. It would be good to tell the students about some constrains and limitations on their design. For example, no containers, lunch boxes, flashlights, candles, lighters, etc. can be used in this activity. Students cannot add, remove, or replace water from the cans. The original water must stay in the cans.

Part 2: Testing their Designs.

- After students have created and drafted their prototypes, pour water in the 4 cans, and place the thermometers in the cans to see the temperature. Students are responsible for reading the thermometer and taking notes of the values gotten. They can read the temperature every 5 minutes to have a stable piece of data. Remind students that their data must be organized since they will have to also provide a visual representation of their results.

Part 3: Data analysis:

- Students will prepare line graphs showing the temperature change in their 5-minute intervals. Have them draw temperature on the y-axis and time on the x-axis. Remind them that the information drawn must be clear, so they should use colors and a good system to represent the data.

- After done the visual representation, students could prepare a short presentation of their results and speak in front of the class explaining the design process they used, what materials they used, why, which ones they think worked right, what things they would do different, etc.
- If you are doing this activity as a competition, you can decide which group won and provide them with a prize. You can calculate the winner by using the following formula to find the percentage of the temperature change:

  - $\Delta T = \frac{TT_{final} - T_{initial}}{T_{initial}} \times 100$

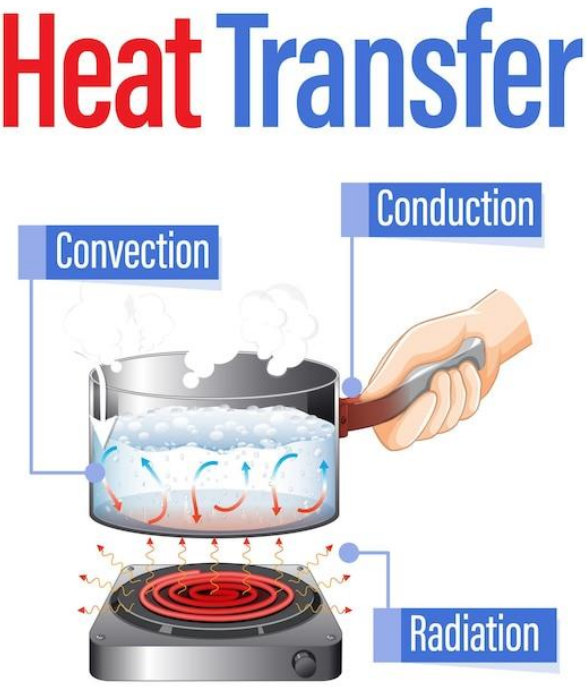
Differentiation/Accommodations

In this activity, instead of using hot glue guns, students could use tape or the classroom teacher could help students, who need it, use the hot glue gun. As per the teacher's guidance, students will be given the choice to express their final conclusions in a range of creative formats, such as poetry, artwork, or any other suitable format they wish to choose. This approach aims to provide a more engaging and personalized learning experience to the students, where they can showcase their creative abilities in addition to displaying their understanding of the subject matter. We believe that this approach will enable students to better reflect on their learnings and convey their conclusions in a more effective and engaging manner.

We can provide students with prompts to help them start their points of view and statements. Some examples of prompts are:

- "A question I have about [concept] is..."
- "In my opinion, the most important aspect of [concept] is..."
- "I believe [concept] is relevant to our lives because..."
- “I think the best way to do this is…”
- “If I could, I would change my design by…”

If a concept is not clear, it would be a good idea to use pictures or videos to clarify doubts or questions.



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DESCRIPTION	COLUMN ONE	COLUMN TWO	COLUMN THREE	COLUMN FOUR
First Feature				
Second Feature				
Third Feature				
Fourth Feature				
Fifth Feature				

Vocabulary/Definitions

Conduction - *The transfer of heat by molecular motion through a solid or a liquid, from a region of high temperature to a region of lower temperature.*

Convection - *The movement of heated molecules of a gas or a liquid from a heat source to another area, due to density differences within the gas or liquid.*

Radiation - *The transfer of heat energy by waves of visible or infrared light moving through space.*

Brainstorm *- A group discussion to generate ideas or to solve problems.*

Prototype - *A first, typical, or preliminary model of something, especially a machine, from which other forms are developed or copied.*

Design: *To form a plan.*

Assessment

A simple, yet effective way to assess this activity is through a class presentation. You can have students present their data, findings and summarizing how their systems worked. Make sure students mention the temperature gain/loss compared to the control cans. Students should be able to explain the reasons why they chose to create or make their designs the way they did it, what changes they made to their prototypes and what was the logic behind their decisions.

Questions

While students are building their designs, you can monitor their processes and also ask questions to understand their progress. You can ask questions such as:

- How much has the temperature changed so far?
- Is this design intended to nullify or intensify the temperature change?
- Why do you think this will work?

References

Dictionary.com. Lexico Publishing Group, LLC.. (Source of most vocabulary definitions, most of which were done in my own words) http://www.dictionary.com

CPALMS Standards and Achievement Standards Network (Source of educational standards) https://www.cpalms.org/Public/search/Standard

http://asn.jesandco.org/resources/ASNJurisdiction

Contributors

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