Exploring Heat Energy (60 min)

Introductory Session with slideshow, animations, activities, and "Keep the Hot Cocoa Hot" Team Challenge

(8 min) Start with the "Exploring Heat Energy" slideshow. (Note: slide numbers refer to the pdf version)

Slide 1: *Instructor Notes:* This slide contains general information about Project SOS.

Slide 2: *Narration:* This program was developed as an introductory session for Project SOS (the Science of Sustainability). The logo indicates that by understanding the three ways that heat moves (conduction, convection, and radiation) we can "hold heat in", control heat loss and "make a difference" in our homes.

Slide 3: *Narration:* Sustainability is an important term that is used by many people to mean a variety of things. What we're mainly talking about is maintaining and sustaining adequate resources for many generations to come, esp. ENERGY resources. Most people don't realize that buildings currently consume 1/3 of the world's energy resources. By 2025, it is predicted they will be the primary consumer of energy worldwide! Therefore, a goal for sustainability is to aim for lower energy use in buildings.

Slide 4: *Narration:* There are many types of energy that we use every day. Can you name them and give examples of how we use them?

Slide 5: *Narration:* So, let's take a look at a typical building…a house. Here are the ways energy is used in a typical house. Which things use the most energy?

Slide 6: *Narration:* You can see that 80% of the total energy used in our homes is directly related to heat energy! Unfortunately, a lot of that energy is wasted…lost to the environment because most people don't understand how heat moves, and therefore how to control it. That loss is both an economical loss and an environmental loss.

Slide 7: *Narration:* With a greater understanding of the science behind heat transfer, we can all make a difference in saving energy. So, Project SOS was specifically designed to address this issue.

Slide 8: *Narration:* Everything is made of tiny particles (atoms and molecules) that are in motion. Therefore, everything has "thermal energy," The word "thermal" comes from the Greek word "therme" for "heat."

Slide 9: *Narration:* Heat and temperature are related, but they are not the same. Temperature measures the average motion (kinetic energy) of the particles in a substance. Substances that are warm have particles that are moving faster than those in cold substances. Notice that the warmer the particles are, the faster they are moving. For gases, as the atoms heat up they become farther apart because they are bumping into each other more, pushing each other away and the gas takes up more space.

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Slide 10: *Narration:* Heat is energy that flows through or between substances when there is a temperature difference. Heat flows from hotter areas to colder areas.

Slide 11: *Narration:* There are three ways that heat energy flows: conduction, convection, and radiation.

Slide 12: *Narration:* What determines how and when heat energy will flow? There are several things to consider:

1. Heat only flows when there is a temperature difference between.
2. Heat flows from hotter to colder.
3. The greater the difference in temperature, the FASTER it flows.
4. Heat continues to flow until everything is at the same temperature (reaches equilibrium)

Slide 13: *Narration:* Let's do an experiment with these items: 2 cups with equal amounts of water, 2 thermometers, and 1 cup "cozy"

Instructor Notes: Have all these items at room temperature: 2 cups with equal amounts of water, 2 thermometers, and 1 cup "cozy." (For details on how to conduct the experiment, see video link: https://www.youtube.com/watch?v=iCqJncMwVSA&list=UUvA1JvEmgV2R8066g7y3sBA)

- Ask participant volunteer(s) to note the temperatures of both cups of water.
- Put the cup cozy on one cup
- Ask…"Assuming the temperature in the room will not change much for the next 20-30 min., what do you think will happen?" Explain that you will now wait until after doing the next part of the program to check temperatures of both cups of water and discuss what happened*

Slide 14: *Narration:* So, what is going on when we "feel cold" or "feel hot?" When our surroundings are colder than we are, heat is going to move from our body to our surroundings, because heat always moves from warmer to colder area. When our body loses heat, we feel cold.

On the other hand, when our surroundings are warmer than we are, heat will move from our surroundings to our body, so our body gains heat and we feel hot.

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Slide 15: *Narration:* Here are some symbols for each of the three ways that heat moves:
Radiation – radiant heat, in the form of light waves, normally in the form of infrared light waves, is given off by all things. In the symbol, heat is shown to be moving by radiation from the fire to a nearby hand.
Conduction –heat moves through an object when the faster-moving particles of the warmer end cause the slower moving neighboring particles to move faster. The symbol shows that heat energy is moving from the warmer end to the colder end.
Convection – heat is transported in air and liquids when a part of the volume of a gas or liquid becomes warmer (as shown by the fire) causing the particles within it to become further apart due to increased energy of the collisions between the particles. This causes that collection of particles to take up more volume and become less dense, which causes it to rise. As the particles cool off when losing energy by conduction or radiation, the distance between them decreases and the volume they occupy becomes smaller causing that collection of atoms to become denser and sink. This creates what is called a "convection current" indicated by the circular pattern in the symbol.

(22 min) *Instructor Notes:* **Continue with the slide show** and stop after showing each animation video to do the activities listed to reinforce each type of heat transfer: ***Always ask…which is warmer, so where will heat move?***

Slide 16: *Narration:* Conduction happens when there is a temperatures difference across an object or between two objects in contact with each other. Here is an animation that describes what's going on when conduction takes place:

Instructor Notes: Show Conduction animation: https://youtu.be/_6LlkgRciak

Follow up with these activities to reinforce the concept. *Always ask…which is warmer, so where will heat move?* (For details about these activities, see video link: https://www.youtube.com/watch?v=aslorCwPPX0&list=UUvA1JvEmgV2R8066g7y3sBA

1. **Camping pad –** (Make the camping connection) *DEMO*. Why do you use it?
2. **Cool to the Touch"** *activity*–ask everyone to touch their tabletop and a metal chair leg at the same time. Which 'feels' warm, which 'feels' cold? Ask them to talk with their team members about why this is happening. Then discuss as a whole group.
3. **Ice Melting Blocks** discrepant event *activity* (from Educational Innovations)
    a. Put a set of two discs on each table
    b. Ask all team members to touch them briefly and place the appropriate notecard (feels colder, feels warmer) beside each one
    c. Ask: If you were to put an ice cube on each one, what do you think would happen? Discuss with your team members and come up with a group decision and explanation.
    d. Have each team explain what they think and why.
    e. Put an ice cube on each disc and watch what happens
    f. Ask them to discuss with their team members why it happened, and then with the whole group – the one that feels colder is taking heat away from your hand very quickly because it is a good conductor, so when the ice cube is on it, it conducts heat from its surroundings to the ice cube very well, making it melt faster.

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Slide 17: *Narration:* **Convection** happens when gases or liquids become warmer (gain heat) and transfer that heat energy as they rise because they are less dense than their cooler surroundings. Here is an animation to show what's going on:

Instructor Notes: Show Convection animation: https://youtu.be/teEiou_sj-o

Follow up with these activities to reinforce the concept. *Always ask…which is warmer, so where will heat move?* (For details about these activities, see video link: https://www.youtube.com/watch?v=_a1P1AFWnrY&list=UUvA1JvEmgV2R8066g7y3sBA and https://youtu.be/E4ViB2wCeCo)

1. **Sleeping Bag or Down coat** – (Make the camping connection) *DEMO*. Why do you use it? Relate this to the earlier 'cup cozy' experiment. The coat does not produce heat, it just keeps you from losing heat by convection!
2. **Hot Air Balloon** – *DEMO*. Using a toaster, some sticks taped upright on it, and a very thin, small, white garbage bag, show how heat from the toaster heat up the air inside the bag, making it expand (warm air particles take up more space because they are colliding more often, pushing each other away) until it is less dense than the cooler air around it…so it floats!
3. **Full of Hot Air –** *DEMO*. Using two small, empty paper bags attached to a balanced rod, heat one bag with a heat lamp and watch how it rises because the warmer air rises, leaving the bag, making it weigh less.
   Instructor Notes: Optional activity – If you don't have the materials to do this as a demo, click on the "Full of Hot Air Demo" link (https://youtu.be/E4ViB2wCeCo) on the slide and play the video with the sound off. Ask "What do you think is going on here?" Then play it again with the sound on if necessary.

Slide 18: *Narration:* **Radiation** happens when all things give off invisible waves of heat energy, mostly as infrared light waves. Here is an animation showing what's going on:

Instructor Notes: Show Radiation animation: https://youtu.be/RtFqo7ORWP8

Follow up with these activities to reinforce the concept. *Always ask…which is warmer, so where will heat move?* (For details about these activities, see video link: https://www.youtube.com/watch?v=cf9lWVTK7Ko&list=UUvA1JvEmgV2R8066g7y3sBA)

1. **Reflective shirt** – (Make the camping connection) *DEMO*. Show how an "OmniHeat" shirt has a reflective lining. Why would you use this? Body heat is reflected back to your body!
2. **Hot Spot Hand Warmer** *activity***–** Put reusable hot packs on each table. Ask them to snap the disc and have everyone notice what happens. (The pack gets very warm). Ask them to do this with a partner: one puts both hands down on table and closes their eyes while the other holds the hot pack just above, but **not touching** one of their partner's hands and see if they can guess which one. Reverse roles if time. This demonstrates that heat radiates from a warmer object to a cooler one.
3. **Space Blanket** *activity* – Have everyone on the team, put hands in the middle of the table and wrap all their hands up with a space blanket. What happens? Why?

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Before showing slide 19 ask: What is the most important and smartest invention ever made? After several suggestions have been made, explain that the thermos bottle is the answer! After all, whenever you put something hot inside it, it will stay hot, but when you put something cold inside it, it will stay cold. How does it KNOW???

(2 min) **Slide 19: Thermos Bottle Physics** – *Narration:* This slide shows all the parts of a thermos.

Instructor Notes: Give students a little time within their groups to discuss why and how it works. Then open the discussion to the whole group. They should see that the parts of a thermos act to slow down all three types of heat transfer, so if the heat is inside, it has trouble getting out, and if it is outside, it has trouble getting in!

- Conduction – glass and rubber are poor conductors
- Convection – rubber stopper, vacuum
- Radiation – silvered surface reflects radiant heat waves

(1 min) * **Now check the results of the cups with water** (one with a cozy and one without) Why did they not change temperature? Talk about why we wear a coat or mittens…are they a source of heat? (This will help them see the if there is no temperature difference between two objects, no heat will flow…and it addresses the misconception that the "cozy" provides heat or warmth, like some kids think a coat or sleeping bag does for them.)

(2 min) **Slide 20:** *Narration:* Let's use what you've learned to do the **Hot Cocoa Team Challenge!**

Instructor Notes: This will be done with each team of 6. Their challenge is to **Keep the Hot Cocoa Hot**! (For details about this activity, see video link: https://www.youtube.com/watch?v=DeXTDKknG0M&list=UUvA1JvEmgV2R8066g7y3sBA

- **Ask: What will be happening to a cup of hot cocoa** if it just sits in a cup. (It will be losing heat…why?...how? Encourage use of terms Conduction, Convection, and Radiation)
- **Explain the challenge and what materials are available**. Show them (don't let them handle anything yet, though) a variety of materials. **Explain that they may only use** 2 of **these materials**: foil, cotton balls, fleece, bubble wrap, newspaper. They may also use scissors and tape.
- Give each team a **paper cup and outer container**.

Then explain:
(3 min) This challenge involves **'roles'** for each pair of you on your team. The roles (described below) are written on slips of paper and put into a 'hat'. (Each **pair of students** pulls one out of the 'hat'.) **All of you will help with the work** since your primary job is to work as a team to do the challenge. However, in addition to that, your **secondary roles are**:

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- ***Building contractor/Conflict solver*** (make sure everyone agrees on what materials to use, gets materials from a table at the front, make sure everyone works cooperatively, no put-downs!)
- ***Timekeeper/Chief Heat Investigator*** (handle the stopwatch and thermometer)
- ***Recorder/ Reporter*** (record and calculate data collected, communicate results)

Give each *Recorder/Reporter* a **data table and pencil** (to fill out and make sketches of what they finally decide to use)

(3 min) Team has **3 min. to discuss what they want to do** to keep the cocoa hot.
Set timer for 3 minutes!

- *Timekeeper/Chief Heat Investigator* - keep time
- *Building contractor/Conflict solver* - make sure all ideas are heard!

(6 min) After time is up, give them **6 minutes to prepare their container**.
Set the timer for 6 minutes!

- *Building contractor/conflict* solver go and get materials
- *Recorder/Reporter* draw and label sketch showing what they used and where
- *Timekeeper/Chief Heat Investigator* keep time and make sure there is a way to insert the thermometer

During this time, set up a **control**: a paper cup inside a container, but without any other materials around it.

(8 min) When time is up, pour hot cocoa into each team's cup and the control cup (teacher or facilitator needs to set timer and measure the temp before and after). Have each *Timekeeper/Chief Heat investigator* **start their timers** and **run for 8 min beginning as soon as the cocoa is poured in the cup**

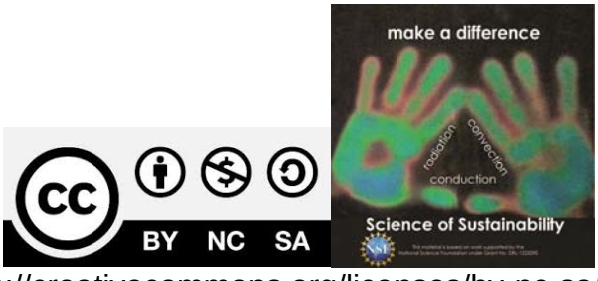
While time is running, discuss with each group while everyone else is listening:

- **What materials your group use and why** (Conduction? Convection? Radiation?).

(5 min) After time is up and results are recorded on the board, **discuss the results** in terms of:

- How their results compare to the control
- What materials they used and how those materials slowed down conduction, convection, and radiation.

Slide 21: Description of Project SOS and contact information.



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