Grade 6 Science - Unit 1 - Thermal Energy

Unit Focus

This 6th grade science unit, adapted from OpenSciEd, explores how different materials and design features affect thermal insulation. Students begin by comparing the rate of temperature change in a standard plastic cup versus a commercially marketed insulated cup. They investigate how variables such as lid design, wall thickness, and the presence of openings influence heat transfer through conduction, convection, and radiation. Through hands-on investigations and simulations, students discover that drinks warm up due to the absorption of radiant energy and the transfer of thermal energy from the surrounding environment, then use this understanding to engineer a container that meets specific performance criteria.

Stage 1: Desired Results - Key Understandings

Standard(s)

Next Generation Science Standards
Performance Expectations: Middle School 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. (MSETS1-4)

Performance Expectations: Middle School Physical Sciences

- Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (MS-PS1-4)
- Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (MS-PS3-3)
- 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. (MS-PS3-4)

Transfer

Students will be able to independently use their learning to...
T1 Create models to explore complex systems, show mastery of key science concepts, and/or develop solutions through creation of a product open to testing and redesign.

Meaning

Understanding(s)

Students will understand that...
U1 Students will understand that the motion of particles in a substance increases when thermal energy is added and decreases when thermal energy is removed, leading to phase changes and temperature differences.
U2 Students will understand that the effectiveness of a material in transferring or insulating heat depends on its properties, such as conductivity, density, and specific heat capacity.
U3 Students will understand that the amount of thermal energy transferred to or from a substance is influenced by the substance's mass and composition, affecting how much its temperature changes.
U4 Students will understand that energy is never created or destroyed; instead, it transfers between objects or transforms into different forms, such as thermal energy or kinetic energy.
U5 Students will understand that designing effective insulation or heat transfer devices requires an understanding of how energy moves through different materials and how design modifications can optimize performance.
U6 Students will understand that light waves interact with materials in different ways—reflection, absorption, or transmission—depending on the properties of the material and the type of wave.

Essential Question(s)

Students will keep considering...
Q1 How does adding or removing thermal energy affect the motion of particles and the state of a substance?
Q2 How can we design and test devices to control the transfer of thermal energy for different applications?
Q3 How is energy transferred between objects, and how does this affect their motion and temperature?

Stage 1: Desired Results - Key Understandings

- Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MSPS3-5)
- Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS-PS4-2)

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- Design: Engaging in a process to refine a product for an intended audience and purpose. (POG.2.2)

U7 Students will understand that engineering is an iterative process, meaning that designs must be tested, modified, and improved based on collected data to achieve the best possible outcome.
U8 Students will understand that temperature is an indicator of the average kinetic energy of particles, and increasing energy input results in greater particle movement, sometimes leading to a phase change.
U9 Students will understand that energy transfer plays a crucial role in everyday phenomena to building energy-efficient structures.
U10 Students will understand that models help explain real-world scientific concepts, such as heat transfer, energy conservation, and wave behavior, by simplifying complex interactions into observable patterns.

Acquisition of Knowledge and Skill

Knowledge	Skill(s)
Students will know... **K1** The motion and arrangement of particles in a substance change when thermal energy is added or removed, which leads to changes in temperature and state (solid, liquid, gas). **K2** Thermal energy is transferred through conduction, convection, and radiation, and different materials transfer heat at different rates. **K3** The amount of energy transferred to or from a substance affects its temperature change, which depends on the type of material and its mass. **K4** Energy is conserved when transferred between objects, meaning that when one object's motion energy increases, another's decreases or energy is transformed. **K5** Materials can be designed and tested to minimize or maximize heat transfer, depending on their conductivity, reflectivity, and insulation properties. **K6** Waves of light can be reflected, absorbed, or transmitted when they interact with different materials, depending on the material's properties. **K7** Engineers use iterative testing and modifications to improve designs, ensuring an object, tool, or process works as efficiently as possible. **K8** Temperature is a measure of the average kinetic energy of particles, and adding energy increases particle motion, while removing energy decreases it. **K9** Different substances respond to heat differently, with some absorbing heat quickly and others resisting temperature changes due to specific heat capacity. **K10** Scientific models help explain and predict physical phenomena, such as changes in particle motion, heat transfer, and light wave interactions.	*Students will be skilled at...* **S1** Developing and using models to predict and describe how particle motion, temperature, and state change when thermal energy is added or removed. **S2** Applying scientific principles to design, build, and test a device that minimizes or maximizes thermal energy transfer. **S3** Planning and conducting investigations to explore the relationship between energy transfer, the type of matter, mass, and temperature change. **S4** Analyzing and interpreting data to explain how changes in motion energy involve energy transfer between objects. **S5** Constructing and defending arguments using evidence to support claims about energy transfer and changes in an object's motion energy. **S6** Developing and using models to describe how light waves interact with materials through reflection, absorption, and transmission. **S7** Using engineering design principles to iteratively test and modify objects, tools, or processes to optimize thermal energy transfer. **S8** Explaining how the type and properties of a material influence how thermal energy is transferred and how waves interact with it.

Stage 1: Desired Results - Key Understandings		
	K11 Vocabulary: Phase, phase change, thermal energy, kinetic energy, thermometer, matter, melting, freezing, condensation, vapor, heat, vibrate, collide, temperature, kinetic energy, energy transfer, conductor, insulator, convection, conduction, radiation, volume, collide, collision, heat conduction, particle, stored energy, transfer, average, thermal energy, potential energy, heat energy, closed system, open system, transformation of energy, thermometer, Fahrenheit, Celsius, conservation of energy, barrier and frequency. (K11)	**S9** Collecting and analyzing temperature and molecular movement data to identify patterns in energy transfer and changes in kinetic energy. **S10** Communicating scientific ideas through models, data, and arguments to explain real-world examples of energy transfer and wave interactions.