Conduction, Convection, and Radiation

Target grades:
6-8

AK ELAM Standards:
Reading for Literacy in Science and Tech.
RST.KI.6-8.3
Writing
WSLST.TTP.6-8.2
WSLST.RW.6-8.10
Speaking and Listening
SL.CC.6-8.1(a,c)
Mathematics
6.SP.2
7.NS.3

Science GLEs:
[6/7/8] SA1.1 & SA1.2

NGSS:
See page 7

Set up time:
30 minutes

Class time:
Two to three class periods

Overview:
Students learn the definitions of conduction, convection, and radiation, and then they perform a science experiment to measure the efficacy of insulation materials. Once the experiment is complete, students will graph their results and draw conclusions from the experiment.

Objectives:
By following the scientific method, students will learn about conduction, convection, and radiation; they will test how well different materials insulate against the cold.

Materials:
Pens/pencils
Vessels to test insulation (3-5 for each group); suggested vessels include: paper cup, ceramic mug, mason jar, tin can, Styrofoam cup, wooden cup, thermos, plastic cup, two plastic cups with some sort of insulation between them (fleece, newspaper, aluminum foil, fiberglass cloth/insulation, etc.) Caution: do not spill any water on the insulation and if using fiberglass, wear safety glasses/goggles and gloves.
Warm or hot water in vessels (about 8 oz. or 1 cup per vessel)
Plastic wrap or aluminum foil (to cover vessels)
Thermometers (one for each vessel or one per group)
Snow or ice water in tubs
Conduction, Convection, & Radiation: An Experiment student worksheet
Lab notebook, notebook, or paper to record notes and data
Stopwatch or clock

Background:
Properly insulating our homes and buildings in Alaska will reduce our energy use and keep us warm. The parts of the house that separate the indoors from the outdoors and keep heat inside form the house’s “thermal envelope.” The thermal envelope includes the walls, floors, windows, and doors.
To better understand how insulation works, students should first learn the difference between conduction, convection, and radiation.
Conduction: Conduction is the transfer of heat through solid objects that are in contact with each other. Heat travels through a solid material across a thermal gradient. Conduction is slowed by insulation.

Convection: Convection is the transfer of heat energy by the movement of a gas or liquid. For example, when warm air comes out of a floor register in a forced air heating system, it rises. This rising of heat is called thermal buoyancy. As the air cools, it becomes denser and falls. This rising and falling movement is called a convection current. This explains why upstairs rooms are often warmer than downstairs rooms. Convection can be interrupted by a physical barrier such as a ceiling. In a typical house in a cold climate, plastic sheeting behind the drywall serves as an air barrier that stops heat losses through convection.

Radiation: Radiation is heat transfer through electromagnetic waves. Radiant heat transfer doesn’t require contact between objects or the movement of fluid. Instead, radiant heat energy is transported through empty space. Sunlight is radiated through space to our planet without the aid of fluids or solids. The heat energy from radiation can be interrupted by a material that reflects it, such as a window coating or aluminum foil.

In order to reduce energy use and heating costs, a home’s thermal envelope must be able to control all three types of heat loss.

Vocabulary List:
conduction - the transfer of heat through solid objects that are in contact with each other. Heat travels through a solid material across a thermal gradient. Conduction is slowed by insulation.

convection - the transfer of heat energy by the movement of a gas or liquid.

convective current - the transfer of heat by the circular movement of a gas or liquid where heat rises through the warm gas or liquid, and then as heat is lost from the gas or liquid, the gas or liquid becomes more dense and falls.

insulation - material used to prevent or interrupt the transfer of energy (including heat, electricity, or sound).

radiation - heat transfer through electromagnetic waves. Radiant heat transfer doesn’t require contact between objects or the movement of fluid. Instead, radiant heat energy is transported through empty space. Sunlight is radiated through space to our planet without the aid of fluids or solids. The heat energy from radiation can be interrupted by a material that reflects it, such as the coating on a window or aluminum foil.

scientific method (scientific process) - the methodological steps involved to pursue knowledge, which includes asking a question, conducting background research, creating a hypothesis, collecting data through observations and/or an experiment, analyzing the data, drawing a conclusion, and communicating the results.

thermal buoyancy - the upward movement of heat.
**thermal envelope** - the shell of the building that acts as a barrier to separate the interior of the house from the outside and limits unwanted heat or mass transfer between the interior of the building and the outside conditions. The thermal envelope includes the frame of the house, insulation, the vapor barrier, and siding.

**Gear Up:**
Discuss the importance of insulation in Alaska, especially during the winter. We insulate our bodies by wearing warm clothing and snow gear to prevent body heat loss; insulating our houses with different materials is a similar concept. Explain the concepts of conduction, convection, and radiation, write these definitions on the board, and discuss ways of insulating homes and buildings. Review the steps of the scientific process with students.

**Activity:**
Tell students that they will work together in groups to carry out an experiment testing how well different materials insulate against the cold. Hand out the *Conduction, Convection, & Radiation: An Experiment* worksheet and go over each step of the experiment including: writing a hypothesis on which vessel will transfer heat fastest, setting up the experiment, conducting the experiment, and recording data and observations in lab notebooks. Divide students into small groups to begin the activity. After students have conducted their experiment, lead them through the graphing and interpretation steps. Students will then write a lab report to communicate their scientific process and results.

**Extension:**
Have students research different insulation materials used in housing and write a report on how to properly insulate a house, discussing the pros and cons of different insulation materials. Make sure they incorporate what they have learned about conduction, convection, and radiation in their reports.

**Additional Resources:**

**Peak to Prairie**
This website contains useful information on insulation and provides the definitions of conduction, convection, and radiation.


**Alaska Insulation Contractors**
This website lists common types of insulation for Alaskan homes.

Cold Climate Housing Research Center
CCHRC conducts research on energy efficient design and construction in northern climates and develops energy efficient prototype homes.

http://www.cchrc.org/

Alaska English/Language Arts Standards:

**Reading Standards for Literacy in Science and Technical Subjects**

RST.KI.6-8.3
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

**Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects**

WSLST.TTP.6-8.2
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
a. Introduce a topic clearly, previewing what it to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.
c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.
d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
e. Establish and maintain a formal style and objective tone.
f. Provide a concluding statement or section that follows from and supports the information or explanation presented.

WSLST.RW.6-8.10
10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

**Speaking and Listening Standards**

SL.CC.6-8.1 (a, c)
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6(7,8) topics, texts, and issues, building on others’ ideas and expressing their own clearly.
a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
Alaska Mathematics Standards:

6.SP.2
Understand that a set of data has a distribution that can be described by its center (mean, median, or mode), spread (range), and overall shape and can be used to answer a statistical question.

7.NS.3
Solve real-world and mathematical problems involving the four operations with rational numbers. (Computations with rational numbers extend the rules for manipulating fractions to complex fractions.) For example, use models, explanations, number lines, real life situations, describing or illustrating the effect of arithmetic operations on rational numbers (fractions, decimals).

Alaska Science Grade Level Expectations:


[6] SA1.2 collaborating to design and conduct simple repeatable investigations.


[7] SA1.2 collaborating to design and conduct simple repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.

[8] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[8] SA1.2 collaborating to design and conduct repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.

Alaska Technology Standards:

T. A 1 & 2
1) use a computer to enter and retrieve information;
2) use technological tools for learning, communications, and productivity.

T. C 1 & 2
1) use technology to observe, analyze, interpret, and draw conclusions;
2) solve problems both individually and with others.

T. E 1 & 6-8
1) evaluate the potentials and limitations of existing technologies;
6) evaluate ways that technology impacts culture and the environment;
7) integrate the use of technology into daily living; and
8) recognize the implications of emerging technologies.
Alaska Library/Information Literacy Standards:

L/IL B 5
5) organize and use information to create a product.

Alaska Cultural Standards:

CS B 4
4) identify appropriate forms of technology and anticipate the consequences of their use for improving the quality of life in the community.
Next Generation Science Standards:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Name or NGSS code/citation</th>
<th>Matching student task or question taken from the lesson</th>
</tr>
</thead>
</table>
| Science and Engineering Practice   | Plan and investigation individually and collaboratively, and in the design: identify independent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4) | Conduction, Convection, and Radiation: An Experiment (Student Worksheet)  
Procedures are outlined for students to conduct a simple experiment. |
| Disciplinary Core Idea             | Temperature is a measure of average kinetic energy of particles of matter. The relationship between temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-4) | Gear-up discussion for the lesson includes conduction, convection, and radiation. The discussion includes temperature as a measure of energy in a system. |
| Crosscutting Concept              | Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-4) | Conduction, Convection, and Radiation: An Experiment (Student Worksheet)  
Procedures D and E. and Step 6 and 7 in Lab report. Students collect and report data on temperature change in the insulated systems they created for their experiment. |

Revised May 2015

Acknowledgment: “This material is based upon work supported by the Department of Energy under Award Number DE-EE0000827.”

Disclaimer: “This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof:”