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IEEE Lesson Plan:

Keep it Cool

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Lesson Focus

Lesson focuses on the engineering behind keeping food and other items cool. Students work in teams to develop a system to make an insulated liquid container that will keep chilled water as cool as possible for an hour using everyday items. Students will need to devise a way to have a thermometer rest in the water and be able to read the temperature throughout the hour. They plan their design, execute and test their system and share their experiences with the class.

Lesson Synopsis

The "Keep it Cool" activity explores how engineers have met the challenge of keeping foods, liquids, and other items cool. Students learn about heat transfer, vacuums, and insulation and design a system to keep a cup of chilled water as cool as possible for one hour. Students compare their results with that of other student teams and reflect on the lesson.

Age Levels

8-18.

Objectives

- Learn about insulation, heat transfer, and vacuums.
- Learn about engineering design and redesign.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- insulation
- vacuum
- heat transfer
- engineering design
- teamwork

Lesson Activities

Students explore how engineers have developed systems to keep liquids cool and learn about heat transfer, insulation, and vacuums. They work in a team to develop a system to keep a cup of chilled water as cool as possible for one hour using everyday materials, share and test their designs with the class and reflect on the experience.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- How a Thermos Works (https://home.howstuffworks.com/thermos2.htm)

Recommended Reading

- Schaum's Outline of Heat Transfer (ISBN: 978-0070502079)
- 1001 Inventions That Changed the World (ISBN: 978-0764161360)

Optional Writing Activity

- Write an essay or a paragraph about engineering has changed the options for insulating homes over the past 200 years.

For Teachers:
Teacher Resource

◆ Lesson Goal
The "Keep it Cool" activity explores how engineers have met the challenge of keeping foods, liquids, and other items cool. Students learn about heat transfer, vacuums, and insulation and design a system to keep a cup of chilled water as cool as possible for one hour. Students compare their results with that of other student teams and reflect on the lesson.

◆ Lesson Objectives
- Learn about insulation, heat transfer, and vacuums.
- Learn about engineering design and redesign.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

◆ Materials
- Student Resource Sheets
- Student Worksheets
- Teacher Materials: ice, water, larger pitcher
- Student Team Materials: thermometer, paper cup with chilled water, various materials to include aluminum foil, plastic sheets, fabric, cotton balls, moss, cardboard, additional paper cups, tape, cups, straws, paper clips, clothes pins, wire, string, recycled packing foam, fabric, rubber bands, and other readily available materials.

◆ Procedure
1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. Teams will consider their challenge and draw a diagram of their planned insulation system on paper.
3. Teams next construct their insulation system allowing for a thermometer to be mounted in a cup with the temperature visible during the one hour test. Teams may request additional materials or parts which surface during the construction process.
4. The teacher will chill water in a large pitcher with ice and take a temperature reading from the pitcher. The teacher should then pour an equal amount of the chilled water (without ice) into each team's cup.
5. Teams will measure the temperature of their chilled water after one minute, and then at various times during the hour. The team with the least change in temperature will be considered to have the best score in the challenge.
6. Student teams draw a chart of their temperature readings, complete a reflection sheet, and share their experiences with the class.

◆ Time Needed
One to two 45 minute sessions. (Note, this lesson calls for a one hour test, but can be adapted to a half hour test if necessary. Also, the devices can be built in one session and tested during another session.)

Student Resource: Insulation, Heat Transfer, and Vacuums

Insulation and Vacuums

Insulation is used for many purposes. Insulation is needed to protect fragile items from being damaged during shipping. It is used to keep cold air out of houses in the wintertime, it is used to separate electric wires, and it is used to keep cool items cool and hot items hot in a vacuum flask. Many materials are used as insulation from fabric to moss to plastic to fiberglass to animal skins. In the case of a vacuum flask, a vacuum serves as the insulation. A vacuum is created when a volume of space is essentially empty of matter; usually when air is pumped out. Light bulbs contain a partial vacuum, usually backfilled with argon, which protects the tungsten filament.

Heat Transfer

Heat can transfer in three ways: conduction, convection, and radiation. Conduction is the transfer of heat by direct contact of particles of matter. Metals such as copper, platinum, gold, and iron are usually the best conductors of thermal energy. Convection is the transfer of thermal energy due to the movement of molecules within fluids. Radiation is the transfer of heat energy through empty space.

Vacuum Flasks

Invented in 1892 by Sir James Dewar, a scientist at Oxford University, the "vacuum flask" was first manufactured for commercial use in 1904, when two German glass blowers formed Thermos GmbH. They held a contest to name the "vacuum flask" and a resident of Munich, Germany submitted "Thermos," which came from the Greek word "Therme" meaning "heat."

A vacuum flask is a bottle made of metal, glass, or plastic with hollow walls. The narrow region between the inner and outer wall is evacuated of air so it is a vacuum. Using a vacuum as an insulator avoids heat transfer by conduction or convection between the two walls. Radiative heat loss is reduced by applying a reflective coating to the surfaces such as silver.

Of course, the flask needs an opening to add or remove hot or cold liquids. Interestingly the most heat or cold loss happens at the stopper. Originally, the stopper would have been made of cork, with plastic being used later because it was more durable and could be formed in a shape to match the opening. A typical vacuum flask will keep liquid cool for about 24 hours, and warm for up to 8. Some vacuum flasks include a fitted cup, for convenience of use with drinks.

Student Worksheet:
Applying Technology to Solve Problems

◆ **Engineering Teamwork and Planning**

You are part of a team of engineers given the challenge of building a container to keep a cup of chilled water from warming up. You'll have lots of materials to use such as aluminum foil, plastic sheets, fabric, cotton balls, moss, cardboard, additional paper cups, tape, cups, straws, paper clips, clothes pins, wire, string, recycled packing foam, fabric, rubber bands, and other readily available materials. Your team's challenge is to develop a device to keep chilled water cooler than other team's devices at the end of one hour. You will need to devise a way to have a thermometer rest in the water and be able to read the temperature throughout the hour.

◆ **Research Phase**

Read the materials provided to you by your teacher, including those that discuss heat transfer.

◆ **Planning and Design Phase**

Think about the different ways you can use the materials provided to keep the chilled water cold. Remember that you need to leave a space for a thermometer to measure the chilled temperature at the beginning, and then one hour after your design is built. In the box below, draw a diagram of your planned insulated cup and include a list of the parts you think you might need. You can adjust this later and also add more materials during construction. Present this plan to your class.

Materials Needed:

Student Worksheet:

Construction Phase

Build your insulation system around the cup with the chilled water provided to you. Remember to figure out a method for keeping a thermometer suspended in the water while still being able to read the temperature. You can make any adjustments during construction that you like, including asking for additional materials you might need. You can also trade materials with other teams if they have extra items you need.

Classroom Testing

Your teacher will chill and the pour an equal amount of cold water into each team's device. Take temperature readings every ten minutes for one hour, and then chart your results in graph format. In the boxes below, mark your temperatures, and then complete the reflection questions.

Original Temp of water	Temp at 10 minutes	Temp at 20 minutes	Temp at 30 minutes	Temp at 40 minutes	Temp at 50 minutes	Final Temp at 1 Hour	Difference in Temperature from original to final

Greatest Difference in Temperature in your classroom	Greatest Difference in Temperature in your classroom

Student Worksheet: Reflection

Complete the reflection questions below:

1. How similar was your original design to the actual insulated cup that you built? What changed? Why?

2. How did your team's temperature variance compare with the rest of the class?

3. If you had a chance to do this project again, what would your team have done differently?

4. What did your graph tell you about the rate of temperature changer for your device?

5. If you could have used one additional component material that was not provided to you which would you choose and why?

6. Did your team make use of any of the things you learned about vacuum flasks in your design? If so, how, and did you think it made a difference?

7. What aspects of other team designs did you find most innovative? Why?

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials
- Light, heat, electricity, and magnetism

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Properties and changes of properties in matter
- Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

For Teachers:
Alignment to Curriculum Frameworks

◆**National Science Education Standards Grades 5-8 (ages 10-14)**

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- History of science

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Structure and properties of matter
- Conservation of energy and increase in disorder
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆**Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Energy

- MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

For Teachers:
Alignment to Curriculum Frameworks

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1 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 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.