Build the Best Thermos

TEACHER NOTES

STEM ACTIVITY

Science, Technology, Engineering and Math Objectives:

- Students will research science topics including:
  - Heat and temperature change
  - Thermal insulators
  - Cooling rate
- Students will engineer and build a simple thermos that will keep an object warm when submerged in an ice bath.
- Students will use appropriate technology to evaluate their design, collaborate with colleagues and present their findings.
- Students will use mathematical processes of:
  - Graphing
  - Linear equation modeling
  - Regression analysis
  - Data analysis

Vocabulary

- Thermal insulator
- Temperature
- Heat
- Cooling rate

About the Lesson

- While using TI-Nspire™ technology, this project based STEM activity will engage your students in the engineering design process:
  - Identify
  - Research
  - Design
  - Create
  - Evaluate
  - Communicate

Tech Tips:

- This activity includes screen captures taken from the TI-Nspire App for iPad. It could also be used with the TI-Nspire family of products including TI-Nspire handheld and software and a traditional wired Vernier temperature sensor. Slight variations to these directions may be required if using other technologies besides the iPad app.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Build_the_Best_Thermos.tns

Activity Materials

- Compatible TI Technologies: TI-Nspire™ Apps for iPad®
- Vernier™ Go Wireless® Temp sensor
- Bottles of various sizes
- Cardboard boxes
- Newspaper
- Plastic bags
- Packing peanuts
- Vermiculite
- Perlite
- Various recycled or trash materials from around your school
- Shredded paper
- Ice cooler
- Refrigerator

Discussion Points and Possible Answers

The Engineering Problem

Your company designs and manufactures extreme outdoor clothing and equipment. Your project manager wants you to investigate insulation materials that can be used to design new products for the company. The insulation material that you recommend will be used in containers to keep food hot or cold and for cold weather sleeping bags and clothing. Your task is to determine the best insulation material for the products and to support your conclusion with test data.

> **Teacher Tip:** Students may find it valuable to explore a STEM career will going through this activity.

STEM Career

A mechanical engineer is a person who applies the principles of engineering, physics and materials science for the design, analysis and manufacturing of mechanical systems. It is a branch of engineering that involves design, production and the operation of machinery.

1. **Identify:** State your engineering goal here. What are you trying to build? What does it need to accomplish? How will you evaluate how well it works?

   Answers will vary

2. **Research:** Use appropriate internet resources to learn about your engineering goal. Your research may include building processes, constraints, potential problems, sources of error, materials, time limits, and scientific principles that apply to your design.

   Answers will vary

3. **Design/Prototype:** Once you have researched the engineering goal, create a plan for the building of your design. Your design may include drawings, labels, materials lists, cost lists, etc. The prototype may be a first-time attempt at building the final product to learn how to put it together. Share your design and prototype with others, listen to their suggestions and decide for yourself the very best design.

   Answers will vary

4. **Create/Build:** Use your design and prototype experience to build your product to your specifications.

   Answers will vary

5. **Evaluate/Test:** Design an experiment that will help you to decide the best design to accomplish the engineering goal. You can use the Vernier Go Wireless™ Temp probe. These wireless probes can be used inside of a refrigerator or cooler. On page 2.2 you will find data collection page for the Temp probe.

   Answers will vary

6. **Analyze:** Determine a method to analyze the collected temperature data that will help you to decide the best design. You might consider: change in temperature, best-fit linear regression, and exponential decay models

   Answers will vary

   a. Why is the slope of this graph negative?

   Suggested Answer: The temperature is dropping as the inside of the container cools.

   b. What are the units of the slope of the graph?

   Answer: ^{o}C/sec

   c. What does the slope of your graph tell you about the thermos?

   Answer: The rate of cooling

   d. What are does the Y-intercept of your graph represent?

Answer: The temperature inside the thermos at the moment it was placed inside the refrigerator.

e. What effect would an excellent thermos have on the rate of cooling of the sensor?

Answer: An excellent thermos would have a smaller slope. (i.e. It would cool slower)

f. How could the data you collected be used to evaluate your thermos?

Sample Answer: The cooling rates (slope of the line) of various designs could be compared among teams to determine the "best" thermos.

Possible results from project evaluation. The Go Wireless Temp sensor was placed in the bottle shown above and put in a refrigerator for 3 minutes. Although this data is not perfectly linear (nor should it be), a linear regression may be a good method of analysis and an appropriate level of mathematical modeling for students.

7. **Refine:** After you have built your design and tested it, think about what you like and do not like about the design. Show your product to your friends and family and listen carefully to their comments. Include the best suggestions from your customer feedback into your design and rebuild your deign to make it better!

Answers will vary

8. **Present:** Prepare a brief presentation of your creation in a cloud-based collaborative environment such as Google Drive. Share your presentation with your teacher, family and friends.

Answers will vary

Wrap Up

When students are finished with the activity, have them email the .tns file to you or upload it to a cloud based collaboration system.

Assessment

- Formative assessment could consist of questions posted to students during the process to determine if they are gathering the necessary information to understand the key vocabulary.
- Summative assessment will consist of the overall quality of the design and student explanation of their model and findings.