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## Student Experience 12: Using the IR Thermometer to Develop Answerable Questions

Ana K. Houseal

University of Wyoming, [ahouseal@uwyo.edu](mailto:ahouseal@uwyo.edu)

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# Using the IR Thermometer to Develop Answerable Questions

## **When**

Prior to the expedition

## **Disciplines**

All sciences

## **Description**

Students learn about and use IR thermometers in the classroom or some place on the school grounds to develop answerable questions. After developing the questions, they perform brief investigations to answer their questions and share their findings with their classmates.

## **Learner Outcomes**

The student will:

- Use the IR thermometer to develop answerable questions
- Perform simple investigations to try to answer their questions
- Share their findings with the rest of the class

## **Materials**

- IR thermometers (Enough so that students can work in groups of 3-4)
- A wide variety of “testable” subjects/objects

## **Emissivity**

All objects emit, reflect, and transmit energy. The only type of energy that can accurately measure surface temperature is the emitted energy. Thus, some measurement errors can be caused by the measurement of reflected energy. Most IR thermometer units have a fixed pre-set emissivity of 0.9, which is the emissivity value for most organic materials and painted or oxidized surfaces. Measuring shiny objects can be problematic. If you want to measure the temperature of a shiny object, you can compensate for errors by covering the surface to be measured with masking tape. Allow time for the tape to reach the surface temperature of the material underneath; the temperature measured will then be the true (emitted) temperature of the object.

## **Background**

### **Infrared (IR) Surface Temperature Thermometers**

What are IR thermometers used for?

IR thermometers can be used to quickly and conveniently measure surface temperatures of objects without physically touching or harming objects being measured. They can also be used to safely measure hot, hazardous, and hard to reach surfaces. Finally, they can provide several readings per second – much more quickly than contact methods.

How do IR thermometers work?

Using the infrared spectrum, an IR thermometer captures the naturally emitted infrared energy of objects. This energy passes through the optical system of the thermometer and is converted to an electrical signal. This signal is displayed as a temperature reading. Several factors determine the accuracy of IR measurements – these are (a) emissivity, (b) distance to spot ratio, and (c) field of view. Each of these is described next. The information provided is for teacher background and is not meant to be presented to students to take notes on, memorize, or be assessed.

### **Distance to spot ratio**

The optical system collects the emitted energy as a circular measurement. Resolution is defined by the distance from instrument to object compared to the spot being measured. This is called the Distance to Spot ratio; D/S. The larger the ratio number, the better the resolution and the smaller the spot size that can be measured. For the STaRRS IR thermometers, there is a 6/1 distance to spot ratio. This means that at a distance of 6" it will measure a 1" spot; or at the distance of 60cm (about 24"), it will measure a 10cm (about 4") spot. The accuracy of measuring a particular spot (say, in a hot spring) decreases with distance, and should be taken into account when considering measurements.

### **Field of view**

Keeping in mind the distance to spot ratio, you can calculate the field of view for your measurements. It is important to make sure that the object being measured is larger than the field of view (or spot size) of the thermometer's measurement. This means that the smaller the object, the closer the measurement should be taken. Ideally, when accuracy is critical, the spot size should be half the size of the object being measured. To locate a hot/cool spot – Aim the IR thermometer outside the area of interest and scan in a regular pattern. It helps to have one person focused on the scanning pattern and another watching the temperature readings.

Finally, a few important things to keep in mind:

- IR thermometers only measure surface temperature. They are not able to measure internal temperatures.
- The reflective properties of glass and shiny, polished metal surfaces affect the accuracy of the thermometer. Avoid taking temperature through glass.
- Steam, dust, and smoke can prevent accurate readings by obstructing the unit's optics
- If the ambient temperature difference is greater than 20°F than the one in which the IR thermometer had been stored, the unit will need 20 minutes to adjust before it will give accurate readings.

Current popular uses:

- Automotive and Home
  - Diagnose car cylinder heads and heating and cooling units
  - Measure furnace and air conditioner performance
- Food Safety
  - Check holding, serving, and storing temperatures

### **Lesson Background**

This lesson provides students with the opportunity to explore science questions using the infrared (IR) thermometer. In addition, students will learn how to develop answerable questions. For this lesson, answerable questions must meet the four criteria below:

- Is it a question?
- Is it safe?
- Do we have the tools/equipment/resources?
- Is the question the right size (manageable)?

Students will practice using the IR thermometer by developing questions about the environment that may be answered by finding the temperature. Class pets, electronics, such as computers that heat up when used, and surfacing materials (asphalt, concrete, grass, shingles, etc.) all make good subjects; however, student should be encouraged to find their own objects to test.

Again, it is important to explicitly point out that IR thermometers measure surface temperature only. Also, IR thermometers often have a laser pointer, which can be used to identify the location of the measurement. For student safety, the laser pointer should be turned off when taking measurements of people and should never be pointed at or near the face. One effective rule that may be enforced is that the thermometer cannot be used to test any temperatures above the waist on people or anyplace on the heads of live animals.

### **Suggested Procedure**

The teacher will:

- 1.** Introduce students to the IR thermometer. Allow each child to use the thermometer to measure the temperature of some object: leg, tabletop, wall, light, etc. Discuss the safety protocol concerning the laser pointer and the need to use °C. (Refer to Celsius Background in the Temperature Tools lesson for benchmark points.)
- 2.** Prompt students to ask questions about “testable” subjects or objects. Help students determine if the questions truly are answerable. For example, if you have a classroom pet, students may ask questions similar to these:
  - a.** Why does the pet like different temperatures?
  - b.** What does the pet eat?
  - c.** Why does the pet like one type of food over another?
  - d.** Why does the pet have fur/scales, etc.?
  - e.** How is the temperature different in different parts of the cage?
  - f.** What happens if I poke the pet here?
  - g.** Why does the pet curl his lip at me like that?
  - h.** What is the range of temperatures inside the cage?

Note that some of the questions above are answerable with the IR thermometer, and others are not. Some of those are answerable using observations; others would be very difficult to answer at all! However, even the answerable ones vary in “answerability.” Work with the students on each question to have them determine if their questions meet the following four criteria:

- a.** Is it a question?
- b.** Is it safe?
- c.** Do we have the tools/equipment/resources?
- d.** Is the question the right size (manageable)?

- 3.** Explain that students will be using the IR thermometer as a tool to answer questions. Help students to generate a set of answerable questions. Guide them toward questions that compare surfaces, or identify ranges of temperatures – for instance, compare a wooden door versus painted wall; investigate microclimates within a pet’s environment, in the classroom, or even in the school yard.

4. Once you have a list of 10-12 questions that you have determined are answerable as a whole group – guide students in determining how they might go about testing their questions. You could take one of the questions and walk through this with them. If your students are new to this type of activity, they will need more specific guidance than if your students already have had many inquiry experiences.
5. Divide the students into groups. Have them decide and record the question they wish to answer. (Note: It is not necessarily important to have each group ask and answer a unique question. Two groups may investigate the same question, if there is physical space for this to happen. This can generate excellent discussions at the sharing point, especially if their data vary at all.) Have students make and record predictions about what they think the answer may be. Have students develop a data table for data collection. This is a good place to talk about multiple measurements – taking measurements in triplicate (and averaging them) is fairly standard practice. Not only does this help with accuracy, it also gives multiple students a chance to use the thermometer.
6. Have students come back to the whole group and have each group share (a) their question, (b) their averaged data, and (c) their results. Discuss other questions that were generated by the activity that they might want to try to answer in the future.

Use this activity as the basis for student-driven research.

**Extensions:**

- Have the students (group or individually) create a list of questions, then exchange with classmates who rate the students as “answerable” or not – and why.
- Discuss the limitations of the IR thermometer (the possibility of reflective energy causing inaccurate readings, distance to spot ratio, field of view issues). Generate some solutions to these problems for future use.

**Reference:**

Allqu Products. (2011). About Infrared Thermometers. Retrieved July 2011 from: <http://www.allqa.com/IR.htm>.