Studying The Instrument Shelter

Purpose

To discover why the instrument shelter is built the way it is

Overview

Students construct shelters that have varying properties and place them in the same location or place similar shelters in different locations and compare temperature data taken in each shelter. Students should predict what will happen for each of the different shelter designs or placements and perform the steps of student research.

Student Outcomes

Students gain an understanding of GLOBE specifications for the instrument shelter and perform a guided inquiry project.

Science Concepts

Physical Science

Heat transfer occurs by radiation, conduction, and convection.

Geography

Measurements of atmospheric variables help to describe the physical characteristic of an environment.

Atmosphere Enrichment

Measurements of atmospheric temperature are affected by the design and location of the Instrument Shelter.

Scientific Inquiry Abilities

Identify answerable questions.

Design and conduct scientific investigations.

Develop explanations and predictions using evidence.

Communicate results and explanations.

Time

One class period for discussion of the shelter and design of an experiment. Two to three additional class periods to experiment with model shelters.

Level

All

Materials and Tools

At least one pair of cardboard instrument shelters for each property to be explored (e.g., cereal container, milk container, shoe box).

Two or more identical thermometers

Depending on the number of characteristics to be investigated, the following materials may be needed:

White paint and black paint (to investigate color)

Two paint brushes (if paint is used)

Heavy-duty scissors (necessary if the shelters must be made from sheets of cardboard and also to investigate the purpose of slits in the shelter)

Paper (to compare the effect of having shelters made of different materials)

Two or more thermometers per student group (depending on the number of properties to be tested at the same time)

String

One or more wooden posts, strong enough to be placed in the ground and hold the instrument shelter (shelters can be nailed onto the posts)

Nails (to attach shelters to the posts)

Hammer

Meter stick

The actual GLOBE instrument shelter (If the actual shelter is not available, students should have the picture and physical description of it given in Instrument Construction, Site Selection, and Set-Up.)

Preparation

None

Prerequisites

An assembled instrument shelter (highly desirable)

Background

While it may seem that air temperature is simple to measure, it is not necessarily easy for many people around the world to take measurements in precisely the same way so they can be compared with each other. Factors such as wind, sunlight, heat radiating from the ground or nearby walls, and moisture can affect a thermometer. So we must protect these instruments by placing them in a shelter built to a specific set of specifications that shields the thermometer from these different influences while allowing it to sense the air . In addition, where this shelter is placed and how the thermometer is placed inside of it are of critical importance.

By following a consistent approach to the construction and placement of GLOBE instrument shelters, scientists and students can be reasonably certain that the temperature differences reported from various areas over time are due to real differences in air temperature. Of course there are some inevitable variations from site to site and GLOBE permits some exceptions to the stringent requirements for placement of the instrument shelter provided these are documented through comments (also termed metadata) and reported to the GLOBE Data Archive.

What To Do and How To Do It

Day One

1. You should start the discussion by asking students to identify the major characteristics of the GLOBE instrument shelter that could influence the temperature inside it. These include:
   - The color of the shelter;
   - The slits in the sides of the shelter;
   - The materials of which the shelter is made.

   The discussion should turn to why the students think these characteristics are important.
2. The discussion of the physical characteristics of the shelter should be followed by a discussion of the placement of the shelter and the thermometer inside the shelter.

   Questions to ask are:
   - Why should the shelter be located away from buildings and trees?
   - Why should it be placed over a natural surface, such as grass?
   - Why should it be placed 1.5 meters above the ground?
   - Why should the shelter be oriented with the door facing north in the northern hemisphere and south in the southern hemisphere?
   - Why is the thermometer not supposed to touch the shelter?

Students should predict the effect that each of the above parameters has on the measurement of temperature (e.g., if the shelter is mounted above pavement instead of grass the temperatures measured will be greater). Then it will be time to test their predictions.

Day One/Day Two (depending on how long the discussions take)

1. Students should be divided into teams. The number of teams will be determined by the number of properties to be investigated, the availability of materials, and the number of students. Up to eight teams could be formed to explore the eight basic parameters discussed above. The more students can be allowed to decide what to investigate and how to investigate it, the closer they are coming to doing full student inquiry.
2. Each team should construct two shelters. This is a simple task if students use ready-made boxes such as oatmeal or shoe boxes, but will be more complicated if they must make shelters from sheets of cardboard.

   If shelters are made from sheets of cardboard, the actual design of the shelter (whether it is a cylinder, like an oatmeal box, or a rectangle, like a shoe box) is not as important as the fact that all shelters should be as close to the same design and size as possible. This is a key lesson in designing student research projects. You always want to keep as many factors the same as possible and choose one to change in a systematic way.

3. Each team should choose or is assigned a property to explore. For those investigating the physical properties of the shelter, further work on the shelter will be necessary. The following are possible alterations to shelters to study their properties:
   – Paint one shelter white and one black;
   – Make one shelter with slits and one without (paint both white);
   – If you are using ready-made boxes, then use white paper to construct a shelter of similar shape and size to the cardboard one. Paint the cardboard shelter white.
   Use a tin can and a box of the same size and shape.
4. Shelters should be mounted on posts near one another and at the same height above the ground unless a team is investigating the effect of shelter height or location. For most teams, the posts do not need to be more that a meter high. The team investigating shelter height above the ground should mount one shelter sitting on the ground and the other one on a post approximately 1.5 meters high.
5. Each team should be given two identical thermometers. Prior to placing the thermometers in their shelters, the students must make sure that the thermometers read the same temperature while indoors. If they do not, then they should switch thermometers to get a pair that do read the same or the students should note the difference between them and adjust their measurements accordingly. For instance, if thermometer A reads 18.0˚ C and thermometer B reads 19.5˚ C when they are next to each other in the classroom, then students should subtract 1.5˚ C from every reading taken with thermometer B during their experiment. Since this is a learning activity, it is not important that the thermometers be calibrated as they must be to take GLOBE data.

Day Three/Day Four

1. Choose a day that is mostly sunny and, ideally, slightly breezy. For most comparisons, you do not want an overcast, rainy, or snowy day.
2. Each team should record the starting temperature of their thermometers. (Again, these should be the same or the differences noted.)
3. Then the thermometers should be placed in the shelters in such a way that they do not touch the cardboard (or paper) surface (unless, of course, the group is exploring the effect of the thermometer touching the shelter wall). If ready-made cardboard boxes are used, the thermometer can be hung by a string from the top of the shelter.
4. Each team should take its two shelters (with thermometers in them) outside. The teams investigating the physical properties of the shelter (color, slits, material) should find an open area away from buildings, preferably an open field. Teams investigating the placement of the shelter will split into two subgroups. One group will place its shelter in an appropriate area (grassy area, away from buildings). The other group will place its shelter in a non-ideal location. That is, to investigate the effects of shelter placement, place: One shelter in an ideal location, one next to the sunny side of a building, one in the middle of a parking lot, or other paved or asphalt surface one shelter at 1.5 meters above the surface, one on the ground at the base of the post.
5. Students should record the temperature from each thermometer about five minutes after placing their shelters. They should then wait another five minutes and record the temperatures again. Temperatures should continue to be recorded at approximately five minute intervals, until the temperatures in the shelters have stabilized and do not change over two successive readings. Note that this may not necessarily

take the same amount of time for both shelters. That is, it may take one thermometer longer to reach the maximum temperature than the other. Therefore, it is important to check both thermometers.

6. Once the temperature has stabilized in both shelters, the students can bring their shelters and their recorded temperatures back to the classroom.
7. Each team should give a brief report of what it found to the entire class and then discuss their results.
8. Each team should write a brief report showing its recorded temperatures. The team should discuss its findings in terms of how the particular parameter investigated affects the temperature and provide any conclusions they can justify about why this is true.

Adaptations for Older Students

For older students: Older students can explore which of the parameters is most important by quantitatively comparing the results from the different pair comparisons. The may also test the combined effect of different changes by making more than two shelters in various categories.

For example, they could test the combined effects of color and ventilation by making one black and one white shelter without slits and one black and one white shelter with slits. They can also explore what effect different weather conditions have on their results. For instance, the experiment could be performed on both a clear day and an overcast day or a calm day and a windy day.

Students could also examine sets of three or more shelters. An example of this might be to place identical shelters next to a building, 5 meters from the building and 10 meters from the building; or there might be shelters with no slits, a few slits, and many slits.

Student Assessment

Students' understanding of the importance of the shelter design and placement can be assessed in terms of:

- The conclusions they draw in their oral and written reports;
- The understanding they show during the class discussions;
- Their ability to deal with such additional questions as: What would be the effect on the white shelter if it became covered with a heavy layer of dust?;
- The validity of the measurements they take.

Students' progress in inquiry can be assessed in terms of:

- Participation and creativity in experiment design;
- Use of math and being quantitative in their analysis;
- How logical is students' reasoning in reaching their conclusions;
- How students discuss and reason about possible extensions to the project.