Lesson 2
How do I measure the distance between objects in the sky?

Overview

Students learn to measure the distance between objects in the sky using their fists. They also use this method for estimating the position of the Moon in the sky. Students also use ratios and proportional relationships to understand why the fist method works regardless of the person's size. The students also measure angles, collect data, graph data, investigate patterns in data, and draw appropriate conclusions from data.

Standards Addressed

NGSS Crosscutting Concepts

- Patterns
- Scale, Proportion, and Quantity

NGSS Science and Engineering Practices

- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions

Common Core State Standards for Mathematics

- 6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
- 7.RP.A.2: Recognize and represent proportional relationships between quantities.

Materials

- Meter sticks (one per pair of students)
- String or yarn, approximately 2m long (one per pair of students)
- Protractor (one per pair of students)
- Measuring tape or ruler (one per pair of students)
- Graph paper or computer graphing software

Lesson Sequence

Engage:

1. Pick an object on a far wall that you ask the students (from their seats) to estimate its length. (A meterstick works well.)
2. Ask students to figure out how many of their thumbs (using widths of thumbs) cover the object from their perspective. (Let students measure how they like at first. You will observe a variety of techniques.)

Explore:

1. Make a plot of number of thumb widths versus distance from object. (Teacher Note: Do not tell students to extend their arms - plots will most likely be scattered).
2. Have students discuss how they took their measurements. Now have each student measure the number of thumbs with everyone's arm fully extended.
3. In groups of 5-10, have groups systematically record the number of thumb widths for the length of the meterstick located at the front of the room. (With large classes, three metersticks at front of room should be used—one for a group of students to the right

of the classroom, the middle of the classroom, and the left of the classroom. This helps to ensure that everyone is making measurements of the metersticks that are directly in front of them.) For organizational purposes, it is helpful if three or four students in the group make measurements from at least eight distances from the meterstick (no distance should be closer than 3 meters from the front.)

4. Have students plot the Number of Thumbs versus Distance for each of the student's data within the group. Using excel is useful for this plotting activity. Discussing dependent and independent variables is also important for this lesson. Number of Thumbs is Dependent and Distance is Independent.

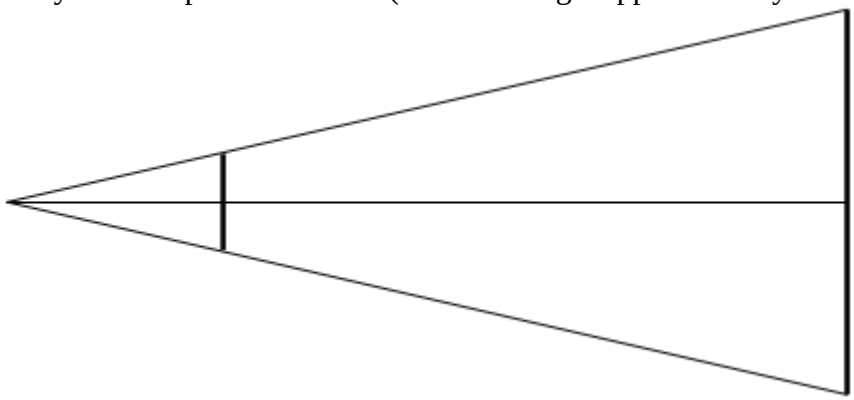
Explain:

Relationship between Number of Thumb widths and Distance

1. Construct and compare explanations of any patterns that emerged in their data. Begin with small group discussion to generate possible explanation and then compare groups' findings within a whole class discussion. (Teacher Note: Students should find an inverse relationship between thumb widths and distance. Students should also see the need for the arm length extension.)
2. Students should notice an inverse relationship. That is N (Number of Thumbs) is proportional to 1/Distance.

Elaborate:

1. For further investigation, use fists (orient fists with thumb side out) instead of thumbs to measure the meter sticks. Have students find a location where their fist exactly covers up one meterstick (no more, no less).
2. Use a protractor and yarn to measure the line of sight angle where student's fist perfectly covers up a meter stick. (You should get approximately ten degrees).



Compare two students' fists at the front of room (choose two students with different sized fists). How can both students measure 10 degrees if fists are different sizes?

3. Have each student measure his/her own fist width and arm length. In their groups, make a table of each person's arm length (best to measure from arm pit to thumb knuckle), fist width, and ration of arm length to fist width.
4. Teacher should have one group member from each group enter group data into class excel plot for further analysis. Plot students' arm lengths versus fist widths to illustrate constant ratios (should be linear).

Other methods of determining degrees per fist width.

5. Also ask students to determine how many fists it takes to go from horizon to horizon? (Teacher Note: This activity leads to altitude angle.)
6. Ask students to determine how many fists does it take to make a complete circle around your body? (360 degrees in a circle). (Teacher Note: This activity leads to azimuth angle.)
7. Select a pair of students to go outside to a pick a cloud and determine a means of using angle measures to communicate to students which cloud they selected without showing other students the particular cloud.
8. Have other students figure out what cloud they picked based on their angular measurements. This will need to be done in a relatively quick fashion since the cloud will move from their original location. (Teacher Note: Teachers will need to discuss azimuth and altitude angles and how they are measured).

Evaluate:

1. Provide opportunity for students to review or reflect on their own learning and other students' thinking.
2. Give students opportunities to discuss alternative solutions.
3. Ask students to write a paragraph in their Moon journals answering the following questions:
    a. Based on what you have learned today, how do people measure the distance between objects in the sky?
    b. How might you use what you have learned today to assist with your data collection of the Moon?