TRB 6:4 - Activity 1 - How Big and How Far

Summary

At the conclusion of this activity students should gain a perspective of how far Earth is from the sun and how large all the planets are relative to each other.

Materials

Cards with the names of the planets and the sun written on them
Nickels, (at least one per student)
90 " yellow or orange model of the sun made of craft paper. (To make the model tape together three 90 " strips of 36 " yellow or orange craft paper. Draw a circle using a string compass made by tying a pencil to a 45 " length of string.) Or if you prefer, have students create the sun model (see Step 3).
Adding machine tape, yarn, string, or other material to measure lengths of 90 inches
You will need models of the planets to scale with the sun being 90 " in diameter. The Earth diameter is represented by the diameter of a nickel (.83 " or 2.1 cm in diameter)). You may get models of the planets in four ways:

(1) Use the chart and make models the size described.

Planet Size with Sun at 90 "										
Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
90	.31	.78	.83	.44	9.27	7.81	3.31	3.21	.15
inches	inches	inches	inches	inches	inches	inches	inches	inches	inches

(2) Use the "Planet Sizes to Scale " images made by the Hansen Planetarium (See below).
(3) Have students calculate and create scale models (Use the same models from "Tour of the Solar System" activity).
(4) Use the Exploratorium website (see Additional Resources) to calculate the scale sizes and distances of the planets and make the models accordingly (You will enter the sun as 90 inches).

Additional Resources:
Out of this World, AIMS, 1994.
This teacher 's guide has many math and science connections for studying space. Blackline worksheets are provided for students ' use. Some activities are "Planetary Scavenger Hunt," "Around the Planets," "Weight in Space," and "How Long Does It Take?" Available from AIMS Education Foundation, P.O. Box 8120,Fresno, CA, 93747, http://www.AIMSedu.org/, 1-888-733-2467
Learning Technologies, Inc. "Solar System Scale Model Kit." Students can use this inexpensive kit to make models of the solar system. A teacher's guide gives step-by-step directions for making models. The kit includes beads, two sizes of marbles, ping-pong balls, Styrofoam balls, two sizes of balloons and a miniature earth globe. Available from Project Star, Learning Technologies, Inc., 40 Cameron Avenue, Somerville, MA, 02144.
Marson, Ron. The Earth, Moon &Sun. Tops Learning Systems.1993.
The activities in this guide include "Great Ball of Fire," "Paper Punch Moon," and "Paper Plate Sun," which teach about relative size and distance between Earth, the sun and the moon. It also includes activities that help explain other core standards. For grades 3-10.Includes worksheets and detailed lesson plans. TOPS Learning Systems, 10970 S. Mulino Road, Canby, OR, 97013.

Background for Teachers

Students often have misconceptions about the relative sizes of objects in the solar system and the distances between them. Inaccurate commercial models, posters, drawings in books, and science fiction movies perpetuate these errors. One of the best ways to dispel these misconceptions is to give students opportunities to record accurate representations. It is difficult to accurately measure to scale both the size of objects in the solar system and their corresponding distances because of the vastness of the solar system.

There are many activities that could be used for students to measure the accurate sizes of objects and distances between them in the solar system. This lesson describes a scale model activity in detail. Several additional activities are also included in the extensions. Ideally, a combination of activities should be used to help students develop understanding and perspective.

The distances of the planets from the sun can be measured in a variety of ways. Because using miles or kilometers requires calculating with very large numbers, one useful measurement is the astronomical unit or A.U. One astronomical unit is the average distance of Earth from the sun. The distance of the other objects in the solar system from each other can be described in numbers of A.U. For example, Mars is, on average, a little more than 1.5 A.U. from the sun and Jupiter is about 5.2 A.U. from the sun. The A.U. distance from the sun for each planet is found in the "Hansen Planetarium Fact Sheet 2002 " (See Materials).

The diameter of the sun is approximately 109 times larger than the diameter of Earth. By coincidence the distance from the sun to Earth is a little more than 107 times the distance of the sun's diameter, or 107 sun diameters. Earth's diameter is approximately 3.5 times the diameter of the moon. The distance from Earth to the moon is approximately 30 Earth diameters. These ratios are useful in calculating relative size and distance.

Again by coincidence, the distances of the planets from the sun are arranged in a somewhat orderly geometric progression. The Invitation to Learn activity uses the approximate ratios of the distances of the planets from each other to get a quick layout of the solar system.

Intended Learning Outcomes

1-Use science process and thinking skills
2-Manifest scientific attitudes and interests
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning
5-Demonstrate awareness of social and historical aspects of science
6-Understand the nature of science

Instructional Procedures

Invitation to Learn:

Ask for 10 volunteers. Ask the class how many planets are in our solar system. Hand each of the volunteers one of the planet cards. Be sure they are NOT handed out in the order they appear from the sun. Have the person with the sun card stand at one end of the classroom and the person with the Pluto card stand at the other end.

Tell the other eight volunteers to arrange themselves so that the planets are in the correct order. Ask the class if they agree with the order. If there are some errors in their arrangement, carefully rearrange the students so that the planet cards are in the correct order.

Next ask students to arrange the planets in their correct relative distances from the sun. Again have the class debate over the correct relative distances. Rearrange the students so that the cards are in the correct relative distance. Uranus should be about halfway between the sun and Pluto, and Neptune should be halfway between Uranus and Pluto. Saturn is about halfway between Uranus and the sun. Jupiter is about halfway between Saturn and the sun. Earth is about 2/3 of the way from the sun to Mars. Venus is about 3/4 of the way between Earth and the sun. Mercury is about halfway between Venus and the sun.

Instructional Procedure:

In this activity students gain a perspective of how far Earth is from the sun and how large all the planets are relative to each other. Earth is represented by a nickel; the moon by a circle made by a paper punch; and the sun by a circle 90 inches in diameter. An advantage of this model is that the sun is very large on a classroom wall and conveys the enormous size of the sun in comparison with the planets. It also shows the vastness of the distance between the sun and Earth, and the relative closeness of the moon to Earth. Students easily remember the size of Earth as a nickel and the moon as a circle made by a paper punch. Earth 's distance from the sun can be located on or near most school playgrounds, and other distant planets are identified by landmarks known to the students or by locating them on a local map.

Show students a nickel and explain that this nickel will represent the size of Earth. Ask students to estimate how large the sun would be. Typically, estimates are much smaller than the actual size. Explain the relationship between Earth and the sun 's diameter. (One sun diameter is 109 Earth diameters.) Challenge the students to figure out the diameter of the sun using a nickel in the calculation. Have plenty of nickels available for students to use in measuring. A recommendation is to make this a problem-solving experience for the students. One strategy students may want to use is to measure a series of nickels (9 or 10,for example) and use multiples to calculate more efficiently. Give students adding machine tape, yarn, rulers, meter sticks, tape measures, etc., to help solve the problem.

Student teams make a single sun diameter using a length of paper strips, string, meter sticks taped together, etc. If teams have varying lengths for the sun 's diameter, the class should work together to come up with a consensus. All of the teams should end up with a length of paper, string, etc., that is one sun diameter long. (Each diameter should be about 90 inches long.)

Show students the yellow craft-paper sun you have prepared. Ideally, you should place the model of the sun at the end of a long hall that has outside doors opening at the far end. Or place it on outside school wall or fence that faces the playground. You may also want to consider having students make the sun model. (See materials for directions.)

Ask students to predict how far Earth will be from the sun model. You may also want them to predict how far away the other planets will be. Using the information that Earth is 107 sun diameters from the sun, have the student teams mark off 107 diameters using their sun diameter strips from Step 2.Have one team of students keep track of the number of diameters as they are marked off. See the charts below for actual distances in both English and metric scales.

Along the way, have students identify the location of Mercury and Venus. You may have to make arrangements to leave your school grounds to reach Earth. Consider marking off the distance to Mars. (It will be about half again as far as Earth.) You will want to identify the locations of the other planets using familiar landmarks. One way to do this is to use a local map to show where planets would be located. Also, you may want to have students use the "Hansen Planetarium Solar System Fact Sheet" average distance from the sun to find the correct distances.

When you have established where Earth is located, have students predict where the moon would be. Students will expect the moon to be farther away than it is. In this scale, the moon would be approximately an arm 's length (.83 inches x 30 earth diameters =24.8 inches). From this model students can see just how close the moon is to Earth compared with the distance from Earth to the sun. Also, have students look back to the sun and note its apparent size. It should look the same size as the sun looks in the sky. (Never look at the sun directly, without a proper solar filter.)

Scaled Distances of Planets								
Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
104	195	269	409	0.8	1.46	2.9	4.6	6

yards	yards	yards	yards	miles	miles	miles	miles	miles
95.2 meters	177.9 meters	246.1 meters	374.8 meters	1280 meters	2350 meters	4728 meters	7407 meters	9728 meters
42 suns	78 suns	107 suns	164 suns	559 suns	1027 suns	2065 suns	3236 suns	4250 suns

In this part of the lesson students will figure out how large the other planets are relative to Earth and the sun using the same scale, Earth is a nickel. Have student teams predict how large the other planets will be in comparison to Earth. To do this assign each team a planet and give them a large double sheet of newsprint. Ask them draw and cut out a circle to represent how big they think their assigned planet is. Tape the models to the blackboard.

Now have the students make the correct size for their planet and compare them to their predictions. You may either give them the correct size for their model or have them calculate the sizes of the other planets (See materials). If you are using the Standard III activity "Tour of the Solar System " you may want to coordinate it with this activity and have students make the planets for both activities. Consider whether to have the final models be two or three-dimensional.

Scale Size of Planets									
Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Pluto	Neptune
.8 cm	2.0 cm	2.1 cm	.6 cm	1.1 cm	23 cm	19 cm	7.7 cm	7.5 cm	.4 cm

Use a local map(s)to identify where the other planets would be located. You can make maps by going to http://maps.yahoo.com (See Materials). Have students orient themselves to the maps and locate the school, nearby landmarks, etc. Have students use scales on the map to locate where the orbits of the planets beyond Earth would be. This is a good time to help students understand that the planets are not in a straight line, but could be any where along their orbits. For fun, students may want to figure out if their own homes are located near one of the planet 's orbit.

Discuss with students what they have learned from this modeling experience. Ask them to tell about new insights or things that surprised them. Have them record what they have learned in their science journals.

Extensions

Have students calculate the travel time to various destinations using different common travel modes such as walking time, car travel time, jet travel time, space craft travel time, or light travel time. First, have them estimate the time. Next have them calculate these times using the “Hansen Planetarium Fact Sheet 2002.” For example, to determine spacecraft time from Earth, calculate the distance of the object from Earth in kilometers. Next, divide that distance by 40,000 km per hour (escape velocity for Earth, a minimum speed that spacecraft need to go). Compute the travel time in days by dividing by 24 and rounding to the nearest day. Compute weeks, months and years in a similar fashion. Students may also calculate how old they would be by the time they reached the destination. (See Out of This World by AIMS Education Foundation for many activities to help teach these concepts.)

Use different scales to recreate the solar system. Some ideas are listed below:

Use the scale beginning with the sun as 1 meter. Calculate the sizes of the planets using the “Hansen Planetarium Fact Sheet 2002 ” for the relative ratios. This is the model used in the GEMS teacher 's guide, Messages from Space: The Solar System and Beyond.

Use the scale with Pluto represented as 1 mm. The sun would be represented by about 53cm.In this scale it is possible for students to pace off the distance to Jupiter. This gives them an understanding of just how far the distances to the outer planets really are.

Solar System Scavenger Hunt. Represent Earth with one spherical object, such as a ping-pong ball. Challenge students to find other objects or balls that are in the correct proportion to represent other planets.

Use modeling clay to show relative mass. Have students use the clay from a can of Play-Doh ™ in this activity. Divide the clay into ten equal pieces. Next combine seven of the balls to represent the mass of Jupiter. Then combine two balls into one ball representing the mass of Saturn. Cut the remaining ball into two pieces that represent Uranus and Neptune. Any small pieces on the knife or left in the can are divided into five pieces representing the remaining five planets. The sun contains about 99.98 percent of the total mass of the solar system. It could be represented by a 13-gallon wastebasket filled with clay. You may want to decorate the wastebasket with a simulated Play-Doh ™ label to cover the large bucket.

Play Solar System Smolf (smash +golf). The object of this game is to knock over water bottles (representing the planets) by throwing a tennis ball at them in the fewest number of throws. Partially fill nine water bottles with water (the more water, the more difficult to knock over). Using the length of the school playground as the distance to Pluto, estimate where each bottle (planet) should be placed. (See Background Information for the approximate ratios.) They do not have to be in a straight line since the planets are not in a straight line from the sun. Students begin at the sun and attempt to knock over Mercury. From Mercury they attempt to knock over Venus, and so on. Student teams count how many throws it takes to knock over all nine bottles.

Show relative distance from the sun to planets using adding machine strips. Give each pair of students a strip of adding machine tape. Together as a class, fold the adding machine tape to represent the following the various distances.

Label one end of the tape “sun ” and the other end “Pluto.” Fold the tape in half and label the fold Uranus. Fold each half in half again. The fold between Uranus and the sun is labeled Saturn and the fold between Uranus and Pluto is labeled Neptune. Fold the remaining paper in half between Saturn and the sun and label this fold Jupiter. Fold the remaining paper in half between Jupiter and the sun and label this fold Mars. Fold the remaining paper in half between Mars and the sun and label this fold Earth. Fold the remaining paper in half between Earth and the sun and label this fold Venus. Fold the remaining paper in half between Venus and the sun and label this fold Mercury.

Assessment Plan

Have students look at printed models or commercial models of the solar system and determine what is correct and incorrect with the models.

Have students create a survey in which they use a model of Earth,such as a nickel,to find how accurate the perceptions are of other people concerning the relative sizes and distances in the solar system.Students compile and analyze their results.

Bibliography

This lesson is part of the Sixth Grade Science Teacher Resource Book (TRB3) http://www.usoe.org/curr/science/core/6th/TRB6/. The TRB3 is designed to be your textbook in teaching science curriculum to your students. This book covers all the objectives of each standard and benchmark. If taught efficiently, a student should do well on the End-of-Level (CRT) tests. The TRB3 is designed for teachers who know very little about science, as well as for teachers who have a broad understanding of science.

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